POWER

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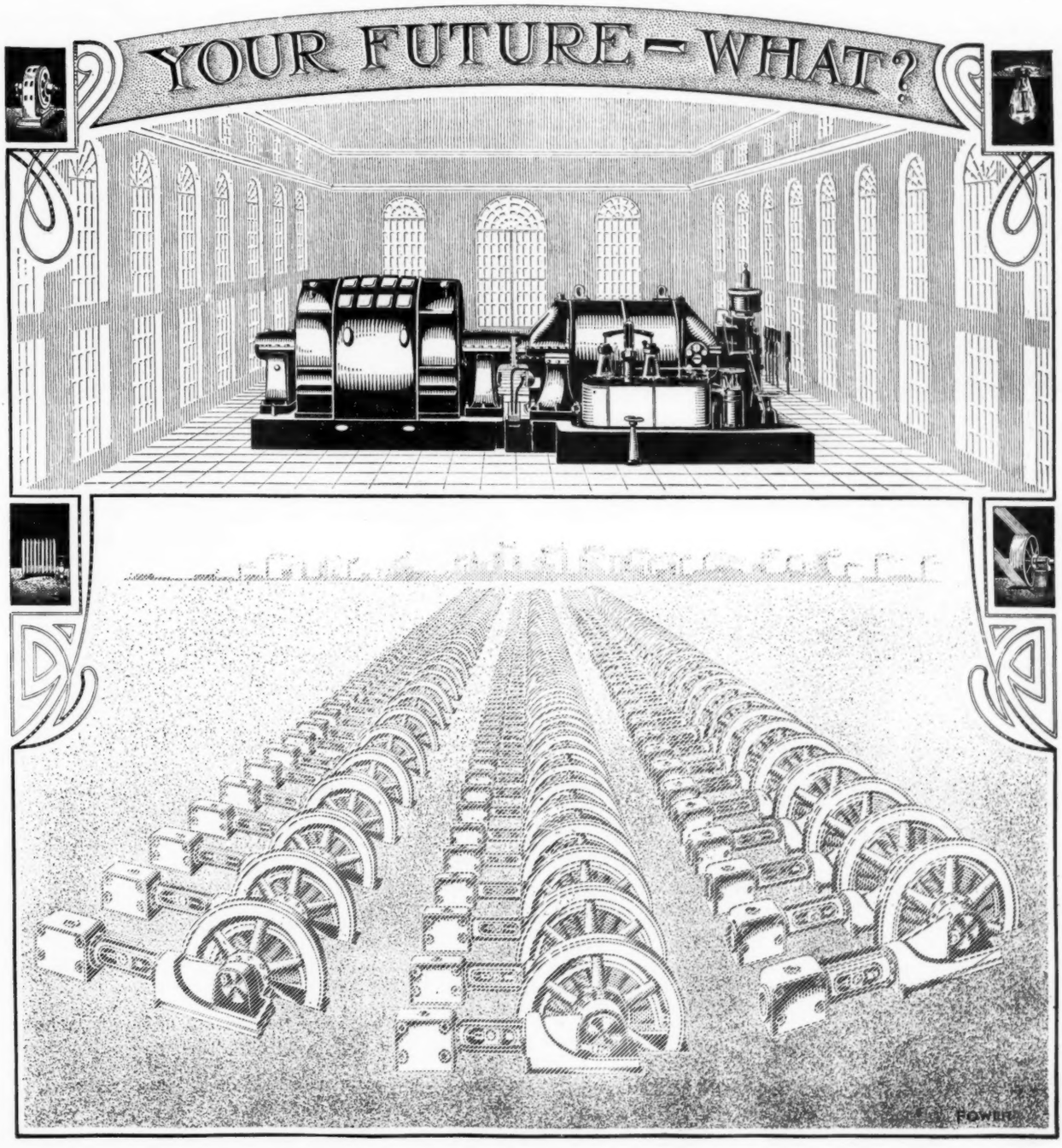


The Capacity of this 20,000-Kw. Turbine is More than equivalent to that of 184 Engines of 150 Hp. Each. Is your plant liable to be absorbed?

Seaview Hospital Plant

By A. D. Blake

SYNOPSIS—A 675-kw. plant supplying 240-volt, two-phase current for power, 110-volt, single-phase for lighting and 240-volt, single-phase for special heating service. Both exhaust and live steam are used for general heating. Refrigeration is supplied by a carbonic anhydride system.

Seaview Hospital, recently completed by the Department of Public Charities of the city of New York for the care of its tubercular patients, occupies a site on Todt Hill, one of the highest points on Staten Island, and in fact on the Middle Atlantic coast. It consists of seven five-story ward buildings arranged in a crescent (see Fig. 1) and connected by covered passages with a kitchen, an administration building, an operating pavilion, a nurses' home and a staff house. A central power and heating plant serves the group through a series of pipe tunnels.

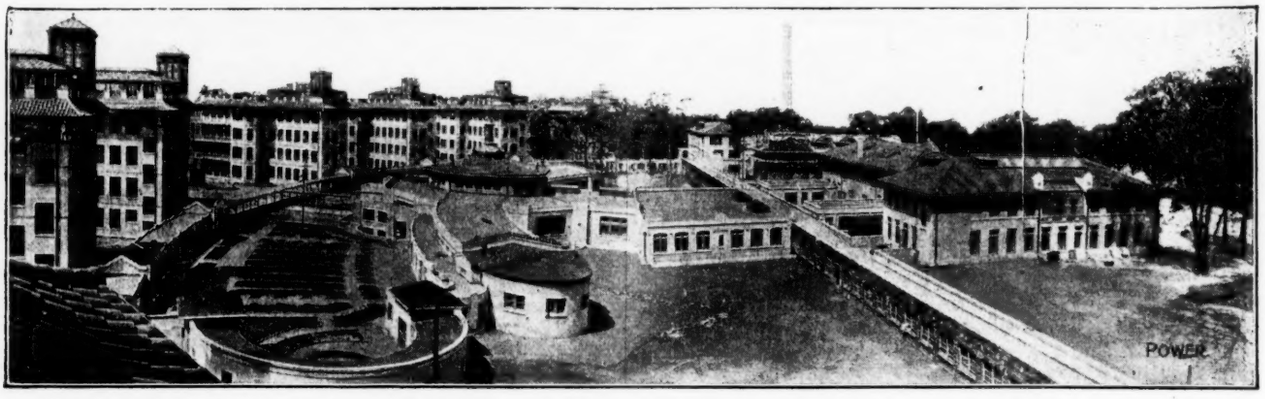


Fig. 1. General View of Hospital Group with Power House in Background

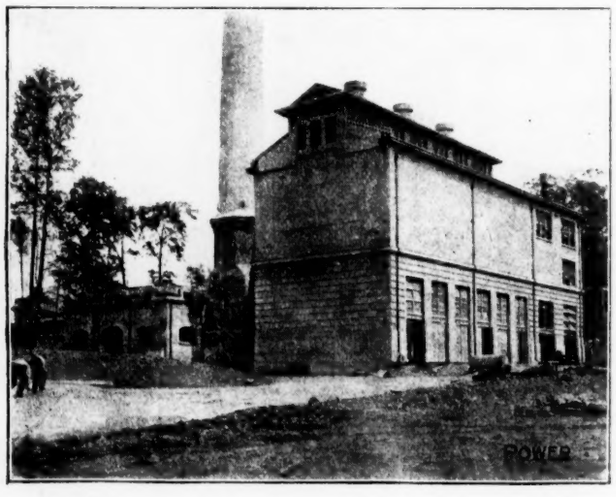


Fig. 2. Power House

As shown in Fig. 2, the power house is of reinforced-concrete construction, with Spanish tile roof and trimmings to correspond in architecture with the other buildings.

When the plans for the institution were first considered, some differences of opinion existed as to the advisability of installing a generating plant or of purchasing electricity from the Richmond Light & Railway Co. The service of the local company at that time, however, was most unsatisfactory and, as all overhead distribution is employed, summer thunder storms often seriously interfered. Aside from the economic aspects of the case, it was imperative that there be uninterrupted service in the operating rooms, which fact was largely responsible for the decision in favor of an independent plant.

Although entailing a somewhat greater cost, a two-phase, four-wire, alternating-current system was selected in preference to the three-wire, direct-current. The chief argument in favor of the alternating-current system appears to have been the desire to render the equipment operative from the breakdown service of the local company.* This has since been disconnected as there is sufficient reserve capacity to insure uninterrupted op-

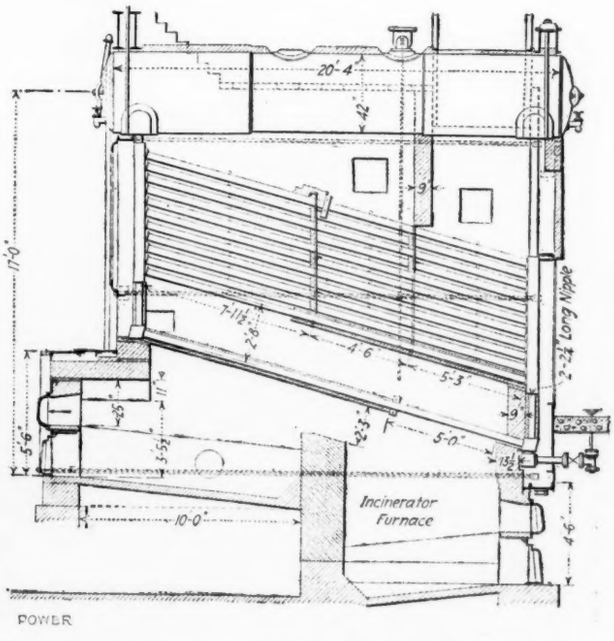


Fig. 3. Section through Special Boiler Setting, Showing Incinerator

*This company is now planning to change over its system to three-phase.

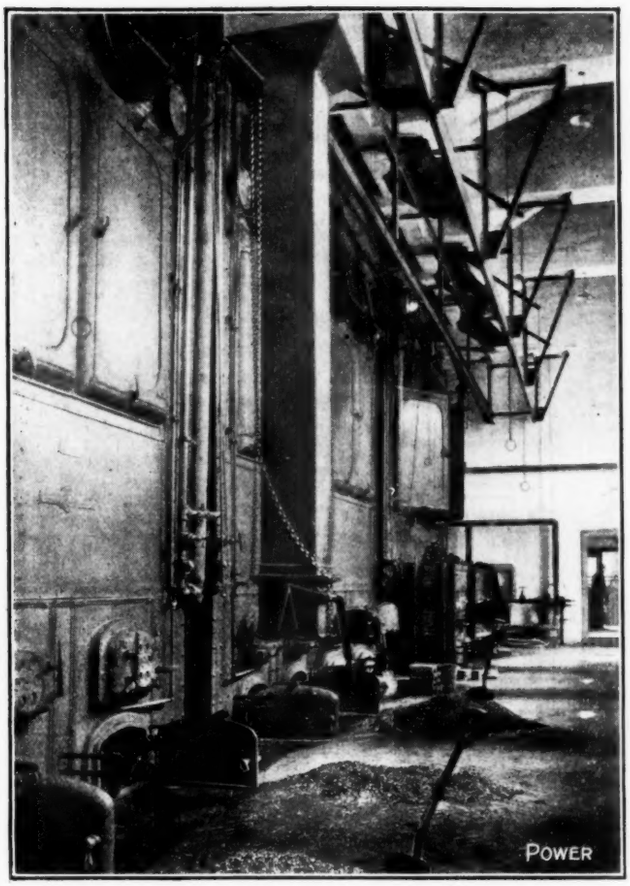


FIG. 4. BOILER ROOM

eration. Before being taken out, however, it did serve for a period of several weeks as a breakdown for the lighting company. This was during the time the Livingston station was badly crippled from a boiler explosion and the hospital plant supplied electricity to a large section of the island.

BOILER-ROOM EQUIPMENT

Steam is furnished at 125 lb. by five 364-hp., B. & W., hand-fired boilers set in a row, in batteries of two, and one single. In order to dispose of the large amount of refuse incident to hospital work, it was believed that the regular boiler plant might be utilized, and accordingly, one of the batteries was provided with a special setting with the boiler fronts extended and an incinerator furnace at the rear, as shown in Fig. 3. With this arrangement it will be noted that both horizontal and vertical baffles are employed. However, the setting has not proved altogether satisfactory in actual operation and it is understood that alterations are contemplated.

In order to burn the anthracite coal freely, under ordinary conditions without forcing, ample grate area has been provided for all the boilers, the grates being 8 ft. 6 in. by 10 ft. long, thus making an area of 85 sq.ft. and a ratio of heating surface to grate surface of about 43 to 1. There are blowers for forcing the fires when necessary.

The flue gases discharge through a breeching at the rear of the boilers to the stack, which is independent of the boiler house. This stack is of reinforced concrete, 175 ft. high and 8½ ft. diameter at the base, representing an area of 0.031 sq.ft. per boiler horsepower and a ratio of stack area to grate area of 1 to 7½.

Over the boilers is a 1400-ton coal bunker which discharges through an automatic weighing hopper and chute to the aisle in front of the boilers. The coal is carted to the plant by automobile trucks from Port Richmond, a distance of about three miles, and is dumped in a hopper from which it is elevated by a motor-driven bucket conveyor to the storage bunker. No special means have been provided for handling the ashes, it being necessary to remove them through the ash doors at the boiler fronts, thence through the boiler room.

There are three 7½ and 4½ by 10-in. duplex boiler-feed pumps supplemented by two injectors, and one open feed-water heater utilizing the exhaust from the auxiliaries, and capable of heating 45,000 lb. of water per hour from 70 to 210 deg. A venturi meter is placed in the feed line.

The boiler feed pumps, hotwell pumps and vacuum pumps are situated in a pit between the engine and boiler rooms.

Steam from the boilers is supplied by two lines, a main and an auxiliary, which come up through the engine-room floor and terminate in a riser to the overhead line from which long-radius branches lead to the throttles of the individual units. This is shown in Fig. 5, the riser being just back of the oil tank.

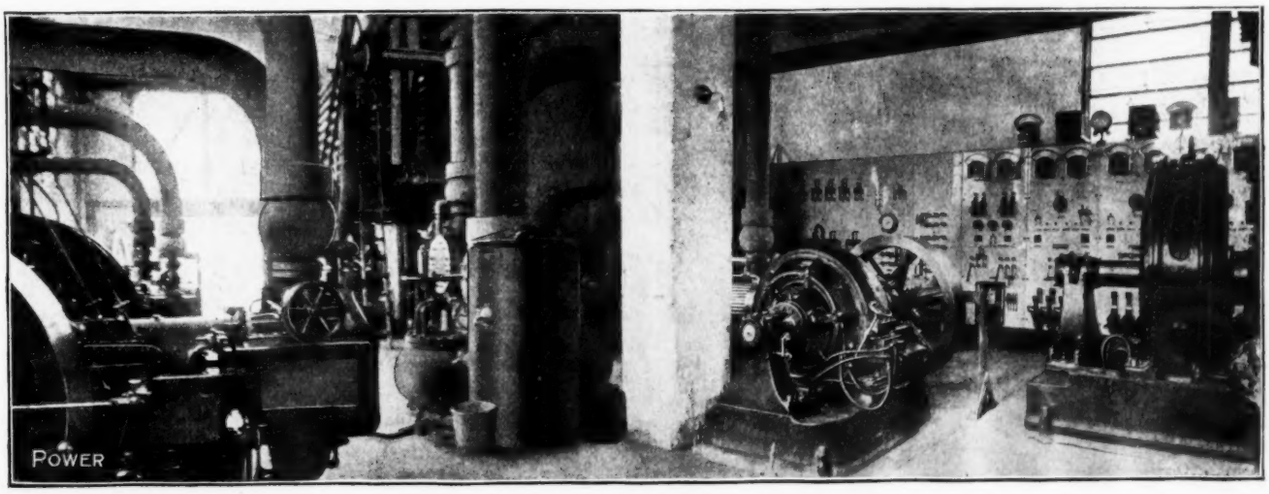


FIG. 5. ENGINE ROOM, SHOWING GENERATING UNITS

Main Generating Units

These consist of three 18 and 28 by 14-in. angle-compound engines directly connected to 200-kv.a., two-phase, four-wire, 60-cycle, 230-volt generators, and a smaller unit comprising a 12 and 19 by 10-in. angle-compound engine driving a 75-kv.a. generator. The larger units run normally at 257 r.p.m. and the smaller one at 300 r.p.m. Excitation at 125 volts is furnished by two 22-kw., engine-driven exciters.

The large units were purchased on a steam consumption guarantee of 22, 24 and 29 lb. of steam per horsepower-hour when running at full, three-quarters and half loads, respectively, under a steam pressure of 125 lb. and a back pressure of 3 lb. The guarantee for the smaller unit under like conditions was 23, 25 and 30 lb.

As is apparent from Figs. 5 and 6, the engine room is badly crowded; in fact, some of the units, particularly the CO_2 compressors, are so placed as to render them almost inaccessible, and in two places it was found necessary to cut holes in the wall, in order to get at the valves. One explanation that has been offered for this crowded condition is that turbines with fewer units were originally contemplated and the room laid out accordingly.

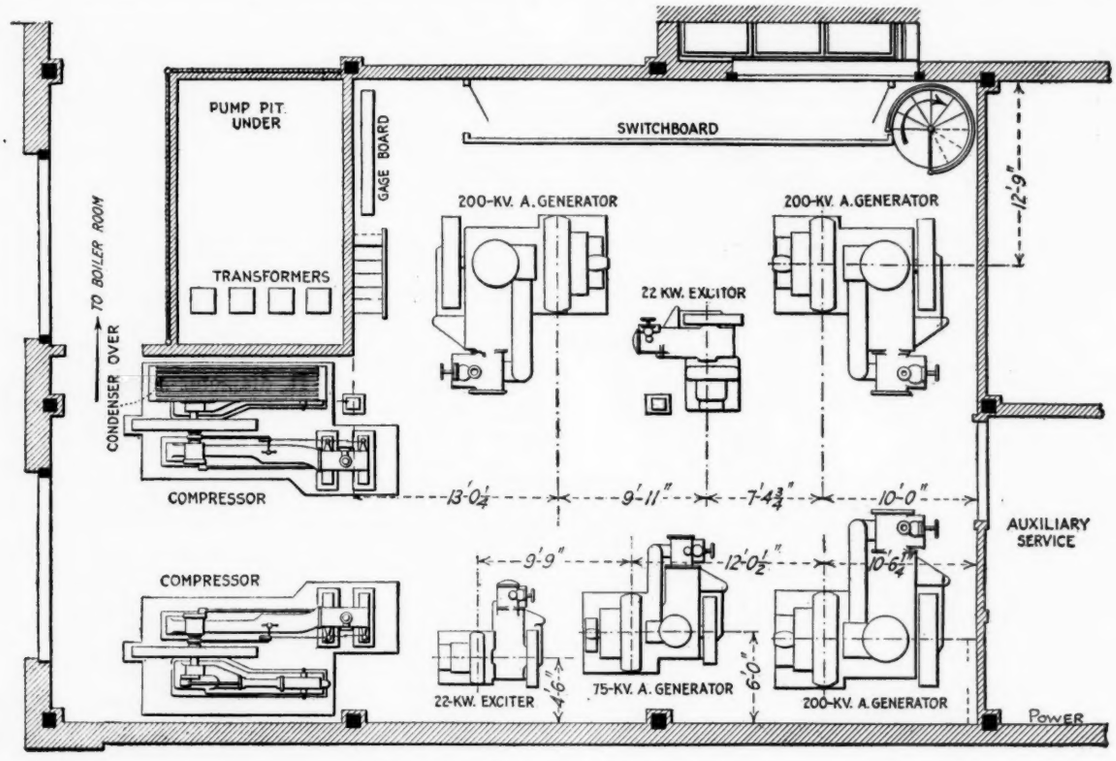


Fig. 6. Plan of Engine Room

Fig. 7. Service Pumps

Heating System and Auxiliary Service

The engines exhaust into a 14-in. exhaust main, which carries steam for heating to the various wards and other buildings. The returns from the heating system are under a vacuum and discharge into the hotwell, from which they are pumped to the heater. A small plunger pump handles the drips.

Live steam at 80 lb. is supplied to the kitchen, laundry and wards, in the latter for sterilizers and food warmers. With approximately 150,000 sq.ft. of radiation, the heating demand in cold weather is far in excess of the exhaust-steam supply and considerable live steam is necessary. However, it is planned to take over the lighting and power load of the Farm Colony adjacent to the hospital, which will help to equalize the exhaust-steam supply and demand.

The ward heating is laid out on the basis of one square foot of radiation to 19 cu.ft. of space. This extremely low ratio was decided upon to meet the peculiar considerations of the service. While it is desirable to have the wards comparatively cold at night, with plenty of fresh air from the outside, it is necessary that they be heated up quickly in the morning so that the convalescent patients may have warm rooms in which to dress.

Cold-water service to the various buildings is supplied by two motor-driven centrifugal pumps, which deliver into two large tanks under an air pressure of from 50 to 60 lb., this air being furnished from an air tank which, in turn, is supplied by a locomotive-type air compressor.

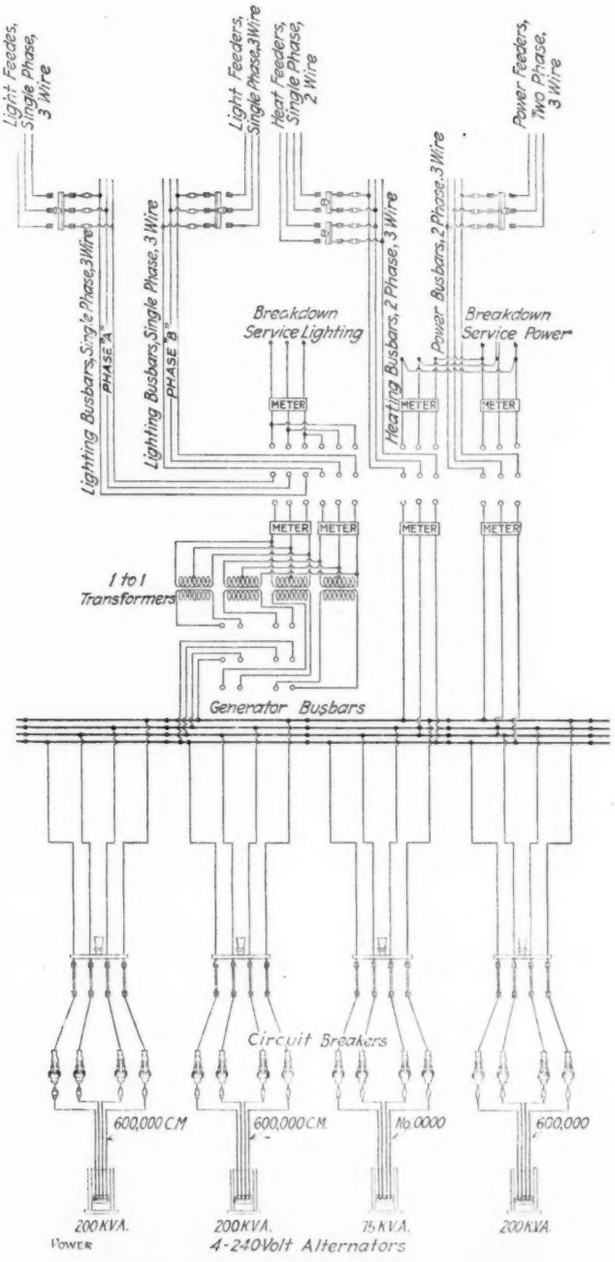


FIG. 8. DIAGRAM OF ELECTRICAL SYSTEM

The motors driving the pumps are of the wound-rotor type and operate automatically through a float control. Since the water level in the tanks is maintained automatically, the drop in air pressure is very slow, hence hand control is employed for the compressor.

Hot water is furnished by two closed heaters, having both exhaust- and live-steam connections and supplying two small motor-driven centrifugal pumps, which circulate it to the various buildings. The water is maintained at about 140 deg. in the heaters. There is a filtration plant for drinking water.

Fire protection is afforded by a large centrifugal pump, capable of delivering 500 gal. per minute against a pressure of 130 lb. This is driven at 1800 r.p.m. by a 75-hp. wound-rotor induction motor, having a drum-type controller.

ELECTRICAL EQUIPMENT

As already stated, the current is generated at 240 volts, 60 cycles, two-phase, and is conducted by four-wire circuits to the generator busbars, from which two 3-wire circuits lead to the power and the heating busbars, respectively. From the former, two-phase, three-wire circuits lead to the various motors and from the latter single-phase, two-wire circuits lead to the laundry, and to the wards for incinerators and for food warmers.

A four-wire circuit from the generator busbars leads to the primaries of four single-phase 1 to 1 transformers. The secondaries connect with 2 two-phase, three-wire circuits supplying the lighting feeders. The circuits in the various buildings are taken off single-phase, two-wire. The object of the transformers is to effect a balance of the lighting load between the phases. Just why the less expensive balancing transformers were not selected for this service has not been satisfactorily explained. Reference to Fig. 8 will make plain the electrical connections.

Three motor-generator sets supply current at 110 volts for the X-ray apparatus and food conveyors and at 10 volts for charging the storage batteries of the tunnel cars.

SWITCHBOARD

The switchboard consists of ten panels—four generator, one exciter, one lighting, one power and heating, and three for feeders and circuits. The leads from the three 200-kv.-a. generators are each 600,000 circular mils

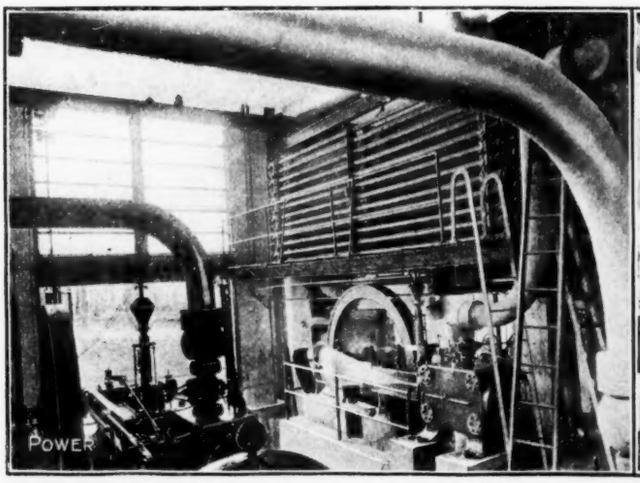


FIG. 9. COMPRESSORS AND CONDENSER

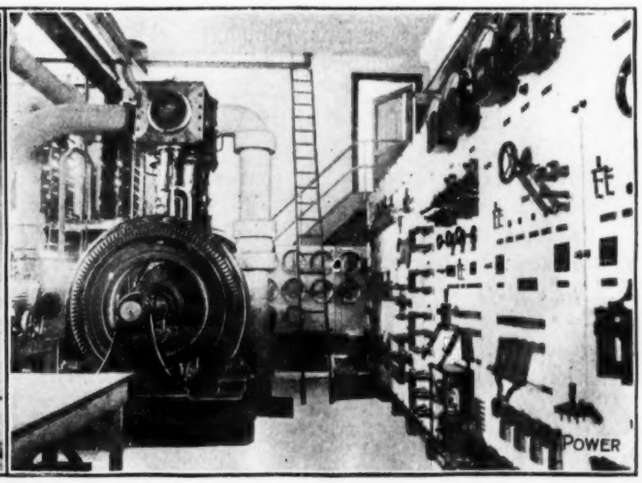


FIG. 10. SWITCHBOARD AND ONE OF THE UNITS

PRINCIPAL EQUIPMENT OF SEAVIEW HOSPITAL PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	B & W, water-tube	346 hp.	Main steam supply	Hand fired; steam pressure 125 lb.	Babcock & Wilcox Co.
5	Blowers	Turbine		Furnace draft		L. J. Wing Mfg. Co.
1	Coal conveyor	Bucket		Receiving hopper to bunker	Motor operated	Conveying Machinery Co.
1	Motor	Induction	10 hp.	Driving coal conveyor		
1	Coal weigher	Automatic		Weighing coal to each boiler		Avery Scale Co.
3	Pumps	Duplex, plunger	7½x4½x10-in.	Boiler feed		Henry R. Worthington
2	Injectors	"Metropolitan"		Boiler feed		Hayden & Derby Mfg. Co.
1	Heater	"Stillwell" open		Heating feed water	Capable of heating 45,000 lb. of water per hour from 70 to 210 deg.	Platt Iron Wks.
2	Pumps	Direct-acting	10x16x16-in.	Vacuum on heating lines		Henry R. Worthington
2	Pumps	Piston	7½x4½x10-in.	Returns from heating system		Henry R. Worthington
1	Pump	Plunger	7½x4½x10-in.	Drips from dry tank		Henry R. Worthington
1	Water meter	Venturi		Boiler feed line		Builders Iron Foundry
3	Engines	Angle-compound	18 and 28x14-in.	Driving main generators	125 lb. steam, 257 r.p.m., noncondensing	American Engine Co.
1	Engine	Angle-compound	12 and 19x10-in.	Driving main generator	125 lb. steam, 300 r.p.m., noncondensing	American Engine Co.
2	Engines	Simple	8x8½-in.	Driving exciters	125 lb. steam, 300 r.p.m., noncondensing	American Engine Co.
3	Generators	Alternating current	200 kv.a.	Light, heat and power	Two-phase, four-wire, 60-cycle, 240-volt	Fort Wayne Electric Wks.
1	Generator	Alternating current	75 kv.a.	Light, heat and power	Two-phase, four-wire, 60-cycle, 240-volt	Fort Wayne Electric Wks.
2	Exciters	Direct current	22 kw.	Excitation for main units	125-volt	Fort Wayne Electric Wks.
1	Switchboard	Marble	10 panels		Lighting: single-phase, three-wire, 120-240 volts Heating: single-phase, two-wire, 240-volt Power: two-phase, four-wire, 240-volt	One half: Fort Wayne Electric Wks. One half: Metropolitan Elec. Mfg. Co.
4	Transformers	1 to 1 ratio	75 kv.a.	To balance lighting load	220 and 110 volts	Fort Wayne Electric Wks.
2	Tanks	Horizontal	7 ft. diameter	House service, cold water		
2	Pumps	Centrifugal	3 in.	Supply house service tanks	50 to 60 lb. pressure	Henry R. Worthington
2	Motors	Wound-rotor, induction	25 hp.	Driving house service pumps	1800 r.p.m., automatic float control	General Electric Co.
2	Starters	Automatic		For motors on house service pumps		Cutler-Hammer Mfg. Co.
1	Compressor	Locomotive type	9½x9½x10-in.	House service tanks	50 to 60 lb. air pressure, hand control	Westinghouse Air Brake Co.
1	Tank		4 ft. diameter	Air supply to service tanks.		
2	Heaters	Cylindrical		House service, hot water	Water at 140 deg.	
2	Pumps	Centrifugal		Hot water supply		Henry R. Worthington
2	Motors	Induction	3 hp.	Driving hot water pumps		General Electric Co.
1	Pump	Centrifugal	500 gal. per min.	Fire service	1800 r.p.m., 130 lb. pressure	Henry R. Worthington
1	Motor	Wound-rotor induction	75 hp.	Driving fire pump	Drum type controller	General Electric Co.
4	Filters	Mechanical		Drinking water		Roberts Filter Mfg. Co.
2	Compressors	CO_2		Refrigeration system	50 atmospheres discharge pressure	Kroeschell Bros. Ice Mach. Co.
2	Condensers	Double pipe		Refrigeration system		Kroeschell Bros. Ice Mach. Co.
2	Engines	Simple, Corliss	10x14-in.	Driving compressors	125 lb. steam pressure	Murray Iron Wks.

and from the 75 kv.-a. machine, No. 0000. Between the generator busbars and each machine are a four-pole switch, a circuit-breaker and fuses, 450- and 250- amp. fuses being used for the larger units and 200-amp. for the smaller one. In specifying the switches, a current density of 800 amp. per sq.in. in solid parts, 100 amp. in stationary contact surfaces and 50 amp. for movable contact surfaces were provided.

Refrigeration System

As a safety precaution, a carbonic anhydride (CO_2) system of refrigeration was selected, since any leak in an ammonia system around a hospital might prove dangerous. With a rated capacity of 60 tons of refrigeration for the 24 hours, this system serves the butcher shop, vegetable coolers, milk rooms, ward refrigerators and a can-ice plant, besides a cooling-water tank from which cold water is circulated throughout the hospital. These services are in multiple, with provision for regulating the temperatures independently.

There are two complete units, each consisting of a double-acting, horizontal compressor driven directly by a simple Corliss engine, and a double-pipe condenser operating on the countercurrent principle. The CO_2 is compressed to 50 atmospheres (750 lb.), and after passing through the condenser, goes to the brine tank, from which the brine is circulated by motor-driven centrifugal pumps.

The general contractor for the hospital was Luke A. Burke & Sons, of New York, with L. K. Comstock & Co. as sub-contractor for the electrical work, this part of the construction being supervised by the Department of Water Supply, Gas and Electricity. William J. Baldwin was consulting engineer on the mechanical equipment for the general contractor during the latter part of the construction, and the architect was Raymond Almirall.

Errata—In the table of principal equipment of the Kentucky Traction & Terminal Co.'s plant, published in the Oct. 13 issue, the 60- and the two 160-hp. turbines driving the circulating-water pumps were credited to the Kerr Turbine Co. They were built by the Terry Steam Turbine Co.

Management in the Boiler Room

By D. F. Cuynne

Careful attention is required in the management and operation of the power-plant boiler room equipped with modern apparatus, such as mechanical stokers, overhead bunkers and ash-handling machinery. As each part must be kept in the best condition, this can be done only by careful attention by the employee who has the handling of the various parts assigned to him.

Good results have been obtained in the plant with which the writer is connected. The plant is in operation twenty-four hours a day; the day load is much greater than the night load. A water tender is in charge of each watch of eight hours, each man being held responsible for the care and cleanliness of the entire fire room and also for one of the stoker engines and feed pumps. He must not only operate this equipment, but keep it clean. No excuse will be taken for leaving the plant untidy or the machinery dirty. In addition to a well kept fire room, the boilers are carefully fired.

It must not be overlooked, however, that to expect the best results from the boiler-room force, the convenience and feelings of the men must be considered. In this plant, every article and tool must be kept in its place. A quadrant and lever are in front of each boiler for operating the damper, and this damper-operating gear gives the fireman no excuse for wide variations in steam pressure or for leaving the front of the boilers. Each man has a chair so that between intervals of firing or cleaning he can rest comfortably. He also has a dust-proof locker for his clothing.

That the men may know that their attention to duty is recognized, they are requested to make suggestions as to operation or need of improvements and they are always accorded a careful hearing. Whenever it is possible, the men are given a day off when they request it for business or recreation; as a consequence, they are seldom absent without permission.

The following instructions for plant operation are carefully carried out by the repair man and others concerned in the daily routine:

1. Test out weekly all boiler settings and brickwork with a candle.
2. Test all injectors each morning and permit them to run for a short time.
3. Keep the openings around the rear furnace cleaning doors closed with asbestos cement.
4. Examine daily all boiler drain and surface blowoff valves for leakage.
5. Examine furnace fires frequently. Grates must be kept properly covered with fuel.
6. Excess clinker must be cleaned out during the noon hour or the night watches.
7. All firing tools must be kept in racks made for them and not rested against the boiler fronts.
8. Remove the draft gages twice a week, clean them out and fill them with clear water.
9. Clinker breakers are to be given a turn by hand every 30 min.
10. Water in all boilers must be maintained at the same level.
11. Steam is to be maintained at constant pressure.
12. Coal siftings must be removed from sifting pits frequently.
13. The floor in the front and the rear of the boilers must be kept clean.
14. Operating stems on the feed valves to the boilers are to be oiled each watch; the operating and track wheels on the coal tanks are to be kept well lubricated; all parts of the coal- and ash-handling apparatus are to be examined every day and kept properly lubricated and cleaned.
15. Back connections of the banked boilers are to be cleaned of accumulated clinkers and ashes during the night watches.
16. When the boilers are shut down for cleaning and repairs, all the valves are to be examined; new brickwork done, if required; clinker breakers examined and repaired; grate bars renewed, if required; all leaking tube caps made tight; baffle bricks renewed where necessary; all tubes in lower row to be thoroughly scraped and cleaned; all soot to be cleaned from tops of tubes; steam drum to be thoroughly scraped and cleaned and superheater to be examined and thoroughly cleaned.
17. Soot is to be cleaned from boilers in service daily.
18. Each stoker engine and boiler feed pump is to be inspected daily and examined weekly.

Universal Hose Tool

For some time J. S. McChesney & Co., of Chicago, have been supplying galvanized steel wire hose bands of various lengths for different sizes of hose. These bands secure the hose to the nipple over which it fits and in the power plant may be used on steam, compressed air or vacuum lines employing a rubber hose. The bands are electrically welded and, when properly tightened by a tool recently designed for the purpose, have withstood on test a direct pull on the hose of 600 lb.

This tool consists of a rod threaded over half its length with a slot in the unthreaded end to receive one end of the band. The other band end is slipped over one of three lugs projecting from a brass sleeve which may be moved lengthwise of the rod by means of a handwheel to which it is attached. The method of adjusting and tightening the band is shown in the accompanying illustrations.

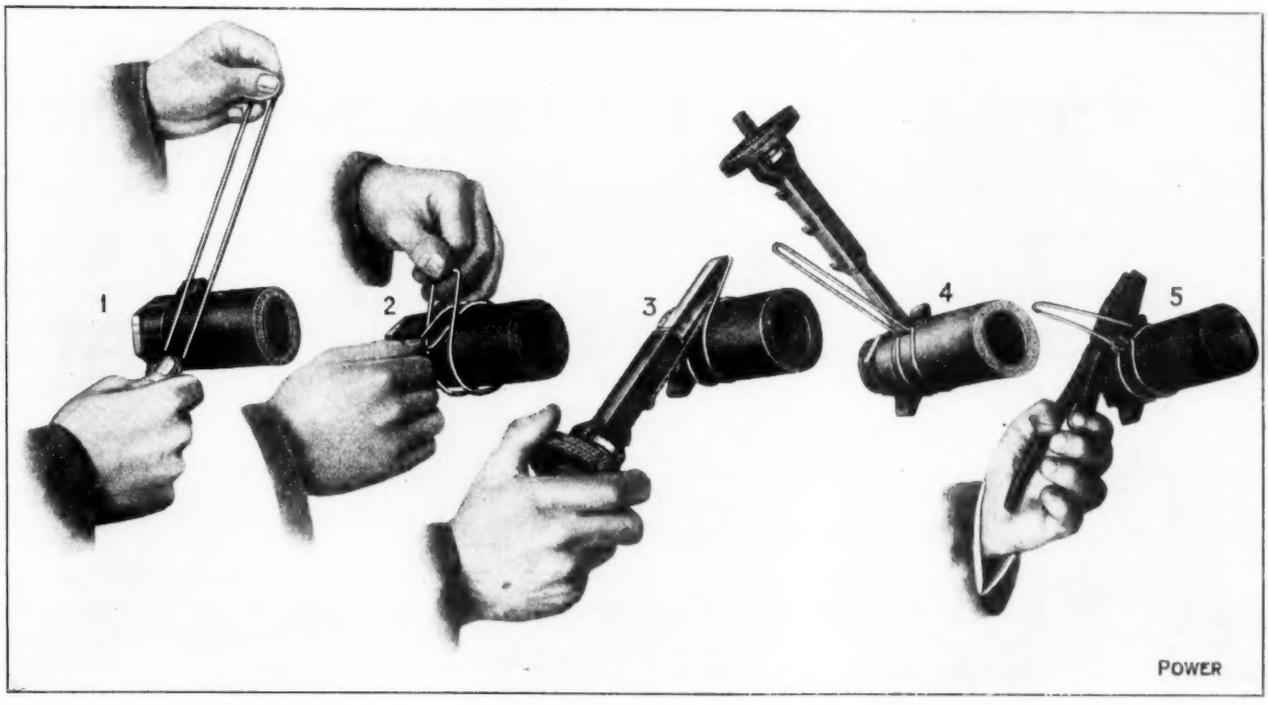


Fig. 1. Placing the Band. Fig. 2. Making the Loop. Fig. 3. Tool in Position. Fig. 4. Making the Band Tight. Fig. 5. Clipping the Ends of the Loop

First the small end of the band is placed on the hose, as in Fig. 1; then the large end is looped over the smaller, Fig. 2, and the tool is placed within the loops, Fig. 3. To tighten the band, the handwheel is turned to the right, and when the proper tension has been secured, the tool is swung up, as in Fig. 4, and removed. The final operation, Fig. 5, is to clip off and turn over the ends.

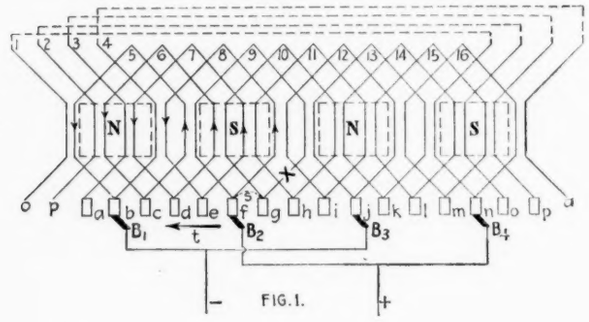
Impulse Wheel for 5412-Ft. Head—Among the exhibits of the firm of Piccard, Piccet & Co., Geneva, Switzerland, at the Swiss National Exposition being held at Berne, Switzerland, is an impulse wheel built for the Fully high head plant of the Société d'Electrochimie, a French company. This is a horizontal shaft wheel which will develop 3000 hp. at 500 r.p.m. Its wheel diameter is 11½ ft. and the jet diameter is 1½ in. The Fully plant will have the highest head water power in the world by a considerable margin. No machine for such severe conditions has been built prior to this one.

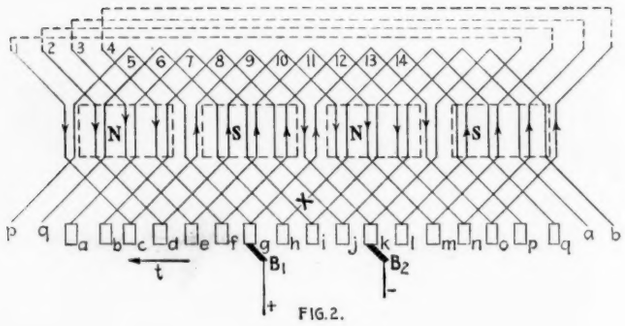
Locating Faults in Direct-Current Armatures—I

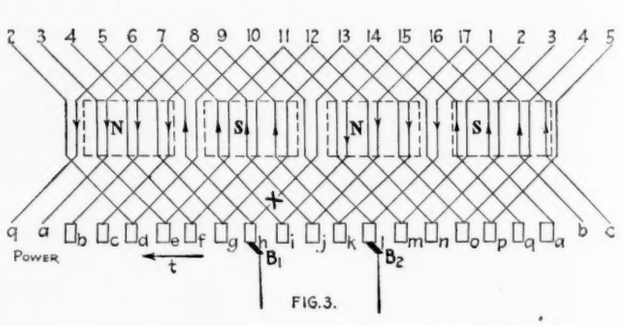
By F. A. Annett

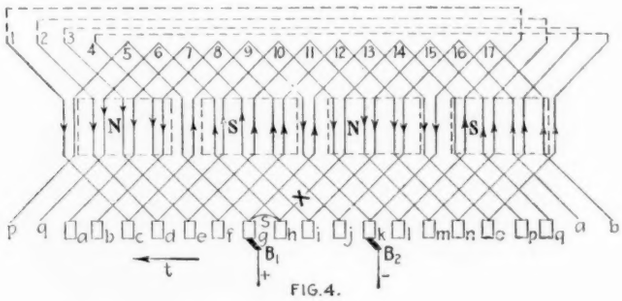
SYNOPSIS—Open circuits in lap- and wave-wound armatures; their detection and means of overcoming the trouble.

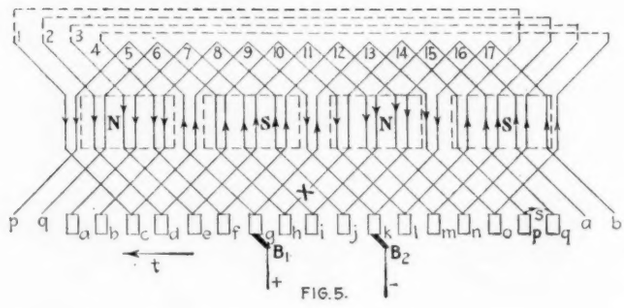
The armature of the direct-current machine is a vital part and probably 90 per cent. of the operating troubles may be traced to this source. Armature faults may be divided into four classifications, namely: Open circuits, short-circuits, grounds and cross-connected coils. The first three may develop at any time, while the last is directly the fault of the workman who made the connections between the coils and the commutator.

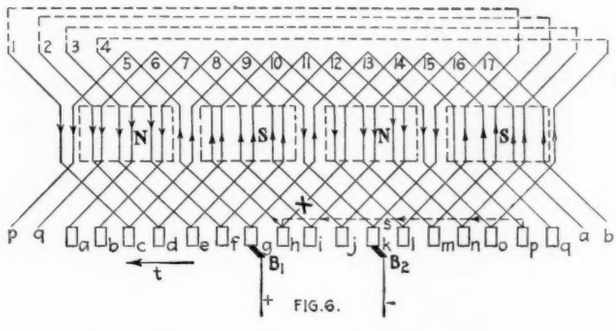












Armature Windings Showing Open Circuits and Current Directions

An open-circuit in the armature winding may occur either in the body of the winding or more often where the coil leads connect to the commutator, the coil leads breaking off up close to the commutator bars. An open coil in the armature will cause severe sparking at the brushes, and the cause of the trouble is usually apparent from the nature of the spark, which is very long and heavy, sometimes, almost reaching from one brush to the other. It soon eats away the mica between the two commutator segments corresponding to the faulty coil and thus gives an indication as to its location. The number of burnt spots on the commutator caused by an open coil in the armature depends upon the way the winding is connected. If parallel wound (sometimes called lap wound) there will be only one burnt spot on the commutator for any open coil in the armature winding. This will occur between the terminals of the open coil, which will be made clear by referring to Fig. 1, showing a four-pole parallel-connected armature winding.

The winding is supposed to be cut through one side and laid out flat on the paper and an open circuit is shown at X in coil 9. By tracing out the current from brush B_2, it will be seen that current can flow from commutator segment f to segment e and on around through the winding to brush B_1, as indicated by the arrow-heads, but cannot flow from f to g; therefore, no current is

flowing from brush B_2 to brush B_3. If the armature moves in the direction indicated by the arrow t, when brush B_2 rests on segment g, current cannot flow from B_2 to B_1 as before, but can flow from B_2 to B_3. This opening of the circuit between B_2 and B_1 and closing between B_2 and B_3, causes a severe spark between segments f and g, which are the segments that the terminal of the open coil are connected to; this, as before stated, gives a clear indication as to the location of the faulty coil.

If the open circuit cannot be located outside of the coil the trouble may be remedied by connecting segments f and g. One way of doing this would be to cut a little of the mica away from between the outside corners of segments f and g with a hacksaw and then expand them until they come in contact with one another across the insulation. A better way is to solder a jumper between the two segments as shown by the dotted line; this conection bridges the break in the armature circuit, and instead of the current flowing from f to g through coil 9, it flows directly through the jumper s.

In an armature which is series, or wave wound, there will be a burnt spot on the commutator for every pair of poles, that is, if the machine has four poles there will be two burnt spots, if six poles, three burnt spots, etc.

In Fig. 2 is shown diagramaticaly a four-pole series-connected armature winding. By tracing out the circuits it will be seen that the winding progresses around the armature in a series of waves. Instead of the coil terminals connecting to adjacent commutator bars, as in Fig. 1, they are connected to bars located approximately two pole spaces apart, or in this case approximately one-half the circumference of the commutator. In the six-pole machine, the coil terminals would be connected to segments located about one-third of the commutator circumference apart, etc.

Coil 14 is shown open at X and by following out the circuit from brush B_1, it will be found that current can flow around to brush B_2 in the path indicated by the arrow-heads, but cannot flow through the path where the conductors are left blank.

If the armature moves in the direction indicated by the arrow t until brushes B_1 and B_2 rest on segments h and l, as in Fig. 3, current will flow in the path indicated by the arrow-heads. In Fig. 3, it will be seen that current is flowing in the conductors that were dead in Fig. 2, and the conductors that were carrying current in Fig. 2 are dead in Fig. 3. This changing of the current from one path to another causes a severe spark between segments g and h, as described in Fig. 1. However, in Figs. 2 and 3, when segments p and q pass the brushes, a spark will occur between them for this is the other end of the open coil. Connecting the two segments together at either end of the burnt spots will close the open circuit, as in Figs. 4 and 5. Fig. 4 shows the break closed by connecting a jumper s between segments g and h, and in Fig. 5 it is closed by connecting a jumper between segments p and q.

In either case this has closed the open circuit but has also cut out a good coil, along with the open one, as it will be seen by tracing out the current that coil 6 is cut out of circuit along with coil 14, which is the faulty one. A better method of repairing the fault would be to connect a jumper across the back of the commutator from segment h to segment p, as at s, Fig. 6. This connects the ends of the faulty coil, which is the only one cut out of circuit, as indicated by the arrow-heads.

Will Quizz, Jr.

SYNOPSIS—Will Quizz wants to know how to determine how much water should be evaporated by coal of a given quality or B.t.u. value.

"The other day, Chief, you told me that each B.t.u. was equal to 778 foot-pounds of work or mechanical energy."

"Yes, that is the mechanical equivalent of heat."

"Well, since then I have been looking up the table of values of various coals and find that they run as high as 15,000 B.t.u. per pound."

"Yes, good coal has that value."

"Then, each pound of 14,000-B.t.u. coal burned per hour should produce

$$778 \times 14{,}000 = 10{,}892{,}000 \textit{ foot-pounds of energy}$$

which would be equal to 5.5 hp. per pound of coal per hour."

"Right you are, Will; if there were no losses in the process it would be possible to get 5½ hp. for one hour from each pound of such coal. What do we get? Is it anywhere near that figure?

"I am ashamed to say, if those figures are right. I guess it is nearer the reverse, 5½ lb. per horsepower-hour instead of 5½ hp.-hr. per pound."

"The full heat value of fuel cannot be realized in practice, but in order to have a basis of comparison, it is necessary to know the thermal limitations, and strive to attain as near the maximum as possible. After finding the calorific value of the coal, the next step in the process is to find the theoretical evaporation of water per pound of that coal. The total heat of steam, as shown in the steam tables, as referred to in our previous chat, makes it possible to predict the limit of the evaporative capacity of any fuel when its calorific power is known. Thus the pounds of water evaporated per pound of fuel burned will be the quotient found by dividing the total heat (above the feed water) in the steam, at a given temperature and pressure, into the calorific power (B.t.u.) per pound of the fuel. For example, coal of 14,070 B.t.u. would evaporate at atmospheric pressure, or from and at 212 deg., nearly 14½ pounds of water.

$$\frac{\textit{B.t.u.}}{\textit{total heat}} = \frac{14{,}070}{970.4} = 14.5 \textit{ lb. of water}$$

"At higher pressure, or with feed water below 212 deg. (either or both), the value of the divisor (970.4) would increase, and with the dividend or the B.t.u. in the coal remaining the same, the quotient representing the pounds of water evaporated would grow less. As an example of the above, suppose that feed water of only 106 deg. is to be made into steam at 100 lb. gage, the total heat would be 1083, to be divided into the 14,070 B.t.u., which would

give only 13 lb. evaporation per pound of the same coal. Of course, this figure is never reached in boiler practice.

"The losses in the boiler room are:

"1. Raising the air from the temperature of the room to that of the gas in the flue.

"2. Evaporating and superheating any water in the fuel and the air.

"3. Heating earthy matter or ash in the coal.

"4. Heating the fresh fuel and gases to a point at which they will burn.

"5. Radiation from boiler setting, etc.

All of the foregoing are practically unavoidable. Others which are more or less preventable are:

"6. Unburned fuel dropping into the ashpit.

"7. Unnecessarily high temperature in the stack.

"8. Incomplete combustion allowing unconsumed carbon and smoke to escape from the stack.

"9. Excess air introduced either below the grate or above it or beyond the bridge wall.

"10. Discharging solid carbon in the form of sparks or cinder from the stack. These, together, may amount to 25 to 35 per cent.

"So you see, Will, it requires eternal vigilance to get anywhere near the possible thermal efficiency of the fuel into the steam. Then there are losses all along the line after that. But the despised boiler is a more efficient piece of apparatus than the engine, notwithstanding the difference in their polish."

Lubrication and Lubricants

By Ray Francis Yates

SYNOPSIS—Tells what characteristics oils should have for different services and how to test them for these by simple methods.

Friction may be defined as the resistance offered to the motion of one body sliding or rolling over another.

Friction and Lubrication

To make the relation between lubrication and friction easily understandable, consider Fig. 1. The body *A* is at rest upon the inclined plane *B*. The angle of the plane is increased so that the friction between the body and the plane will just prevent the body from sliding down. The static friction (friction of rest) between the body and the plane will be dependent upon three factors—i.e., the conditions of the surfaces, the degree of the angle of the plane and the weight or pressure of *A*. If the angle is increased to a point where the body gains motion, it will be found that the kinetic friction (friction of motion) is much less than the friction of rest. With the introduction of a lubricant between the body and the plane, the angle may be decreased and yet the body will gain motion. After the introduction of the lubricant the friction will no longer take place between the body and the plane but between the surfaces of the plane and the lubricant and the body and the lubricant. Molecular or internal friction also exists in the oil and increases with the viscosity of the lubricant, if an ultra-viscid oil was introduced between *A* and *B* it would tend to retard motion rather than to assist it. The coefficient of friction is the ratio of the force of friction to the normal pressure. The coefficient of friction for dry or poorly lubricated surfaces is independent of the area of contact and the velocity.*

In a well lubricated bearing the amount of friction is not constant; it varies with the velocity and the temperature. The friction tends to decrease until a temperature of 75 deg. F. or over is reached, and in most oils after it is reached, the friction increases quite rapidly. This is due to the oil losing its viscosity through excessive heat, thus causing it to become so thin that it is squeezed out of the bearing and the conditions of a dry bearing are approached. The temperature at which different oils are affected depends upon the properties of the oils.

In the lubrication of machinery, the lighter the shaft and the greater the speed, the less viscid will be the oil required to lubricate it. If an extremely heavy or viscid oil were introduced between the bearings of a small spindle traveling thousands of revolutions per minute, the cohesive force relative to the molecular construction of the oil would be far too great and could not be overcome without an increased amount of friction between the surfaces of the bearings and the lubricant. But, if a thin oil were used to lubricate large bearings carrying great pressure and operating at low speed, the reverse conditions would result. The oil would not possess sufficient viscosity to remain between the surfaces but would be squeezed out and a hot bearing result. When the pressure is small and the speed great, a lubricant of low viscosity is to be desired. When the pressure is great and the speed low, one of great viscosity is to be sought. In most cases, it will be found that high pressures are intimately connected with slow motion and light pressures with greater motion.

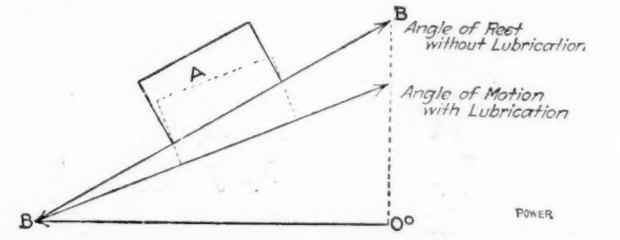


Fig. 1. Illustrating Friction With and Without Lubrication

Too much stress cannot be laid upon the importance of selecting a lubricant for a specific purpose—one that will in every way meet the conditions under which it is to operate. An oil prepared to withstand the high temperatures of gas-engine lubrication could not be successfully employed for another purpose. If a manufacturer prepares an oil for low-temperature use it could not meet the requirements of gas-engine lubrication, for that oil

*When speaking of the coemcient of friction being independent of velocity, it is used only when referring to kinetic friction, as static friction is greater.

possesses certain properties which it can retain only when operating under the conditions for which it was intended. An oil for low temperatures is worthless for high temperatures, for the oil would immediately lose its viscosity and carbonize. When an oil carbonizes, the hydrogen passes off in its natural state—a gas, leaving the carbon a solid, impure mass.

Selection of Lubricants

In the selection of lubricants, the conditions under which they are to be used should first be approximated—i.e., pressure, speed and, in some cases, temperature. It is the practice in many places to use the same oil on small, high-speed machines as on the hangers of the line-shaft. The universal use of one oil in any plant is due to ignorance rather than economy.

Animal and Vegetable Oils

The compositions of animal and vegetable oils are extremely complex, being mixtures of organic salts of organic acids, alcohols and hydrocarbons. They appear both as oils and fats, but their solidification is merely a physical property and entirely dependent upon temperature. These oils are referred to by many chemists as "glycerides" as they are capable of yielding glycerine by the process of saponification.

Vegetable oils are divided into two distinct classes, the volatile and the fatty oils. Their identification may be readily learned by a very simple method. Volatile oils will not leave a fixed stain upon paper; fatty oils will.

Vegetable and animal oils are little used today as lubricants, being almost entirely replaced by hydrocarbons. With the increase of manufacture by machinery and the dawn of motor traction, these oils soon become scarce and expensive.

Mineral Oils

Hydrocarbons or mineral oils are, as their name implies, compounds of hydrogen and carbon, the general chemical expression being C_nH_{2n+2}. These two common elements unite in varying proportions to form many hydrocarbon compounds, each with its individual characteristics. The more heavy or viscid mixtures are used extensively as lubricants. The American petroleum-producing sections are Pennsylvania, Ohio, California and Ontario. Certain parts of Russia are also rich in petroleum. While hydrogen and carbon are the chief constituents of petroleum, nitrogen, oxygen and sulphur are also found; sulphur is a very objectionable ingredient. Ohio, California and Canadian petroleums contain some sulphur.

Methods of Testing Lubricants

In the following paragraphs are explained the more important tests and their simple execution.

Viscosity Test—Viscosity is the degree of fluidity, depending upon molecular or internal friction. It is relative to the internal properties, cohesion and adhesion. The greater the amount of cohesion between the particles of oil, the greater the pressure the oil will be able to withstand before its particles are broken. Adhesion is also an important function, and is the amount of affinity an oil shows in attaching itself to foreign bodies or surfaces. The closer an oil will adhere to the surface of a bearing, the better it will resist the pressure on it. It is essential that a good lubricating oil possess a fairly high degree of adhesion—that is, a good lubricant to a reasonable extent must be both adhesive and cohesive, the two properties being intimately connected with viscosity. It is generally conceded among oil dealers and users that an oil, to be a good lubricant, must have a high degree of viscosity. This is erroneous. The viscosity should be in proportion to the weight or pressure under which it is to be used; great viscosity for heavy pressures, and *vice versa*. Some oils break down in places when forming a film between bearings. The increased friction which will result from this raises the temperature objectionably and lowers the viscosity. With one condition assisting the other the bearing will soon give trouble.

Oil viscosity is determined by two different principles. One depends upon the time required for a given quantity to pass through an orifice of standard dimensions; the other is based upon the resistance to motion offered a rotating disk by the oil. Because of the simplicity and accuracy of the former method it is universally used.

A common and simple method of testing the relative viscosity of different oils without any especially designed apparatus is to fill a glass pipette with the oil to be tested and record the time it requires to run out. This method is accurate enough in comparing oils, and can be enhanced by keeping the oil temperature uniform.

Flash Tests—The flash point is important, especially if the lubricant is to be used under high temperatures. The usual way to test for flash point is to heat a small quantity of oil in an evaporating dish over a bunsen burner. The temperature should not rise over 8 deg. F. per minute, as accurate results cannot be obtained. After the temperature has reached about 150 deg. F., a small flame should be brought near the surface of the oil and applied at every one or two degrees rise. Presently, a snappy, blue flame will shoot across the surface of the oil. The temperature should be recorded at the appearance of the flame as that is the flash point. A flash point of 350 deg. F. is sufficiently high for oils for ordinary lubrication; lubricants for gas engines should have a flash point of over 500 deg.

Burning Point—If heating the oil is continued and the flame applied at regular intervals, the blue flame will appear more frequently and increase both in frequency and volume in ratio to the rise in temperature. When the temperature reaches a certain degree the flame fails to automatically extinguish itself and remains on the surface. This should again be carefully noted; it is the burning point.

Another method of obtaining the burning and flashing point of oils is the "closed flash test," and is carried out in an inclosed compartment heated in the usual manner. The results differ fifteen or twenty degrees.

Evaporation Test—A small quantity of the oil is carefully weighed, placed in a small, open dish and subjected to a temperature of 212 deg. F. in a closed compartment for 24 hours. For accurate results the temperature should be kept as uniform as possible. The oil is then reweighed and the amount evaporated learned by subtracting its original weight with the latter result. Between 0.25 and 0.5 per cent. is a common amount for an oil to decrease. Any oil losing more than 3 per cent. should be regarded with suspicion. When cylinder oils are being tested it is customary to increase the temperature to 350 deg., weighing every hour and noting the

rate of evaporation. A cylinder oil losing 2 per cent. in 50 or 60 hours is quite safe.

Specific-Gravity Test—The two most common methods of learning the specific gravity of an oil are by means of the hydrometer and the specific-gravity bottle, the latter being by far the more accurate.

A small, thin glass bottle will serve the purpose admirably. The exact weight of the bottle should first be recorded; then it is filled with the oil and again carefully weighed. The weight of the bottle is then deducted from that of the bottle and the oil combined, the result being the weight of the oil. Then the bottle is emptied, all traces of the oil being removed and the bottle filled with the same amount of water. (This may be done by properly marking the bottle or filling it until it overflows.) The bottle is then weighed and its weight again deducted, giving that of the water. The weight of the oil is then divided by that of the water, the result being the specific gravity. Thus:

	Grams
Weight of bottle and oil	41.535
Weight of bottle	10.363
Weight of oil	31.172
Weight of bottle and water	44.235
Weight of bottle	10.363
Weight of water	33.872

$$\frac{\text{Weight of oil } 31.172}{\text{Weight of water } 33.872} = 0.9203 \text{ specific gravity of the oil.}$$

This is an important test in identifying oils.

Acid Test—Acids in oils are common and most undesirable. Many oils find their way upon the market polluted with sulphuric acid, resulting from improper washing at the refinery. Oil containing an appreciable amount of this acid should be regarded with extreme caution, for the acid is a severe corrosive agent.

Acid may be readily detected by thoroughly mixing a small quantity of oil with an equal amount of pure, warm water. The mixture should then be tested with neutral litmus paper. If acid is present the paper will immediately turn red; its sensitivity may be greatly increased by introducing it into the fumes from nitric or hydrochloric acid till it becomes partly red. After it is dried and part of its surface is immersed in the oil to be tested the very smallest amount of acid will turn the part immersed just a shade darker than the rest.

Friction-Testing Machines—It is customary with many large manufacturers and railroads to severely test oils under the conditions under which they are to be used before purchasing them. This is accomplished in an oil-testing machine—i.e., a machine in which the operating conditions are made so flexible that the speed and pressure of the bearing it is proposed to be used on may be attained. If its behavior is carefully noted while being tested, its possibilities while working under the specified conditions may be accurately ascertained.

The Thurston oil-testing machine is a standard type in America, being used by the United States Navy as well as by many railroads. This machine is pictured in Fig. 2. Analyzing it mechanically, it consists of a shaft revolving between the bearings B, B_1 and B_2. The pressure on the bearing B can be regulated by adjusting the coiled spring C. The amount of pressure exerted upon B is indicated by the dial D. A thermometer is attached to register the exact temperature of the bearing. The machine is rotated by the cone of pulleys E. Oil is introduced into the bearing B and when the shaft is brought into motion it causes a displacement of the pendulum K along the graduated arc FF. The displacement of the pendulum will be in ratio to the amount of friction offered by the oil in the bearing. The less the deflection of the pointer on the scale, the greater the lubricating value of the oil. The arc is so graduated that, by dividing the reading on the dial by the pressure shown on the index D, the coefficient of friction is given. This is an accurate method and avoids mathematical complications.

Graphite

For many years the value of graphite as a lubricant has been recognized and its commercial application has received impetus on the appearance of the fine artificial

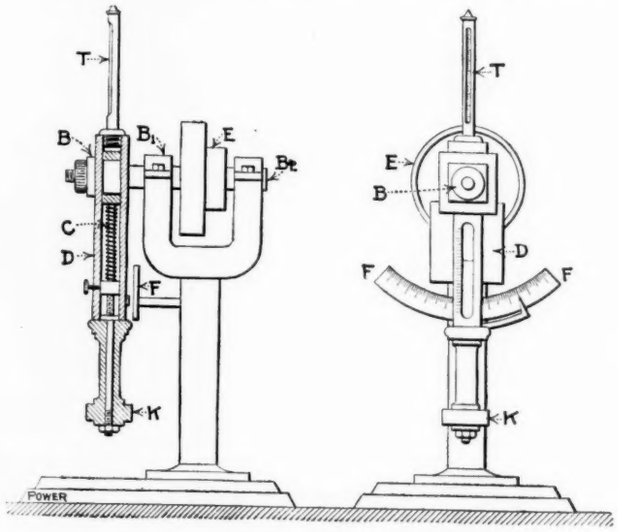


Fig. 2. Thurston's Friction Machine

product produced at the very high temperature of 7500 deg. F. It was while carrying on experiments in an electric furnace with his product carborundum that Dr. Acheson noticed that when the substance was carried to a temperature far beyond that of its production, decomposition occurred and the silicon portion of the carborundum would dissipate as volatile matter, the carbon portion remaining as pure graphite.

Today, graphite is being disintegrated to such an extreme degree of fineness that it requires 339,000 of its particles to extend one inch. In this condition of subdivision it will remain suspended in solutions; also these particles pass unimpeded through filter paper.

Colloidal Graphite as a Lubricant

Oil containing colloidal graphite constitutes a most dependable source of lubrication. When introduced into a bearing the graphite particles, being infinitesimal, penetrate the pores of the metal. These particles accumulate until the surfaces in contact are completely amalgamated with a thin graphite veneer which has been termed a graphoid surface. This film, unlike that of oil, is free from intrinsic friction and exceedingly stable in its construction, being capable of withstanding far greater pressures than any form of hydrocarbon regardless of its viscosity. The graphoid surface not only greatly reduces friction but practically eliminates wear. So lubric is the nature of this graphite film that upon its establishment oil consumption may be considerably reduced. If

the oil supply of a bearing is either accidentally discontinued or completely consumed, the graphoid surface alone will hold up as a lubricant for a long time, preventing a hot bearing.

It has been found, after many exhaustive tests, that 0.35 per cent. of colloidal graphite properly diffused in oil is sufficient.

Colloidal graphite in gas-engine lubrication possesses many advantages over plain oil. The formation of carbon deposits on cylinder walls is due to the inability of the piston to effect a thorough wiping back of the lubricating oil and a portion remains in the cylinder and is decomposed. This source of trouble usually ceases with the use of colloidal graphite. The minute particles immediately enter the interstices of the metal and form a soft, unctuous film that is unattainable by any mechanical operation. Of course, with the establishment of this film there must be an almost perfect fit between the piston and the cylinder walls, effecting a more thorough retreat of the oil. The temperature of a gas engine in operation, although very high, produces no effect upon graphite either physically or chemically as it is refractory capable of withstanding 7600° F. before any signs of vaporization are shown.

Automatic Cutoff Recorder

By F. W. Salmon

Much can be done in the power plant toward ascertaining what the power is costing and by gathering useful data later by employing such instruments and appliances as can be purchased or improvised at little expense.

Fig. 1 shows a cutoff and power recorder that can be easily arranged for use with a Corliss engine. The pencil *A* is secured to the governor dashpot rod by clamping

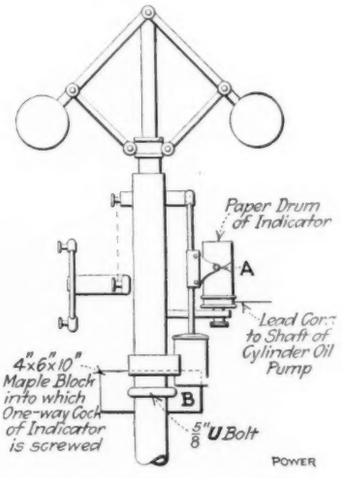

Paper Drum of Indicator
A
Lead Cord to Shaft of Cylinder Oil Pump
4"x6"x10" Maple Block into which One-way Cock of Indicator is screwed
B
5/8" U Bolt
POWER

Fig. 1. Arrangement of Indicator

a piece of sheet tin to the rod with two bolts. The tin has sufficient spring, if suitably proportioned and adjusted, to keep the pencil against the paper without producing too much friction. A one-way cock is secured to the wooden block *B*, clamped to the governor column by a U-bolt. The indicator is coupled to the one-way cock in the usual way. The regular piston and pencil motion of the indicator is not used.

Almost any device that will wind the drum (or release it) about three-fourths of a revolution in about twelve hours at a uniform rate, will answer for moving the paper drum. In some cases the paper-drum cord may be wound on the cylindrical oil-pump shaft; a float in a pail or can of water from which the water is allowed to slowly drain is convenient. Then, again, one end of the cord may be wound around the hour-hand spindle of a cheap clock clamped to the engine frame or other convenient part.

The indicator drum is revolved by its own spring, the speed being controlled by the clock. The engineer makes a small mark with a pencil against the pencil on the governor dashpot rod at various periods, say at each hour, for convenience in reading the chart afterward. Before starting or after stopping, a base line should be drawn

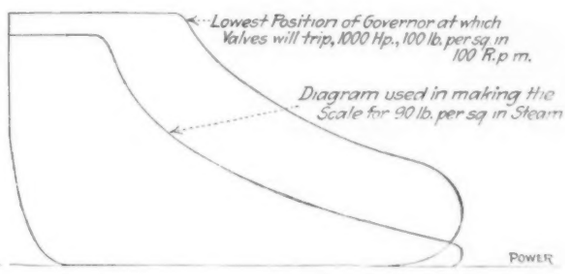

Lowest Position of Governor at which Valves will trip, 1000 Hp., 100 lb. per sq. in 100 R.p.m.
Diagram used in making the Scale for 90 lb. per sq. in Steam
POWER

Fig. 2. Diagram for Reading Scale

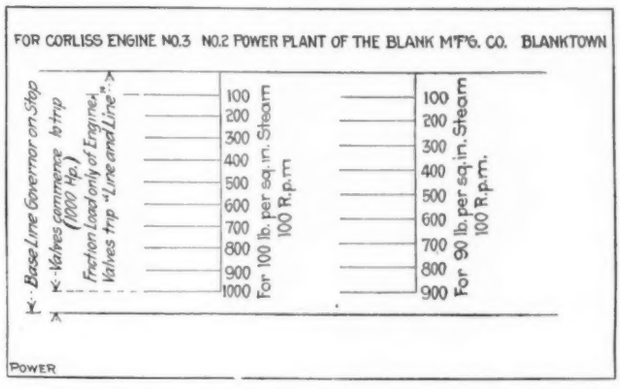

FOR CORLISS ENGINE NO.3 NO.2 POWER PLANT OF THE BLANK M'F'G. CO. BLANKTOWN
Base Line Governor on Stop
Valves commence to trip (1000 Hp.)
Friction Load only of Engine
Valves trip "Line and Line"
100 200 300 400 500 600 700 800 900 1000
For 100 lb. per sq. in. Steam 100 R.p.m.
100 200 300 400 500 600 700 800 900
For 90 lb. per sq. in. Steam 100 R.p.m.
POWER

Fig. 3. Celluloid Horsepower Scale

in the usual manner as with the ordinary indicator diagram.

The scale for the chart is easily obtained by taking indicator diagrams from both ends of the cylinders at the times or points noted on the chart, then calculating the indicated horsepower. By taking diagrams and finding the power at several heights of the governor in this way, a curve can be easily drawn (Fig. 2), and the power indicated and recorded automatically by the governor scaled off quickly at any time. Celluloid is good material on which to draw the chart scales, Fig. 3, as it can then be placed over the diagram and a reading taken.

It is not intended to use such a power recorder continuously throughout the year, but for a week at a time several times a year, or when for some special reason it is desirable to obtain such a record.

Usually, if the steam pressure is kept fairly uniform, it will not be necessary to make corrections for the slight variations, but a number of scales may be drawn on the celluloid chart for several steam pressures if desired.

Oil-Engine Drive for Existing Ice-Making Plants

By Robert P. Kehoe

SYNOPSIS—An argument, supported by figures, for the oil engine as motive power for can-ice plants, especially in localities where coal is relatively high.

Since the successful installation of so many new ice-making plants of capacities ranging from 15 to 400 tons daily, with oil-engine drive, the question of applying this type of motive power to existing plants arises. There are steam-driven distilled-water can plants in operation which produce six or seven tons of ice per ton of coal burned under the boilers. There are also plants of the same type which produce only three or four tons of ice per ton of coal, but the majority probably average about five tons of ice for each ton of coal.

If coal can be purchased for $2 or $2.50 per ton, it is difficult to show much saving with oil-engine drive, but where coal costs $3 or $4 per ton, the saving is considerable. The price of oil must also be considered, as the relation between the cost of the two fuels will decide whether or not the change will be an advantage.

In some localities, such as California, coal costs $5 or $6 per ton, while oil can be bought for 75 cents per barrel. The saving here would be enormous, but as oil is also used under the boilers instead of coal, the comparison should be made between the relative amounts of oil used.

Assuming average conditions and taking the price of coal at $3.50 per ton, and oil at 3½ cents per gallon, the following table will serve as a basis in determining the amount of saving possible by installing oil-engine drive to take the place of steam power in existing distilled-water can plants. The figures also cover the cost of changing the plant to a raw-water system:

TABULATION SHOWING INITIAL COST AND SAVING OF APPLYING OIL-ENGINE DRIVE TO EXISTING DISTILLED-WATER CAN-ICE PLANTS

Ice-making capacity in tons per 24 hr.	15	25	50	100
Approximate horsepower of engine for machine and all auxiliaries	60	100	200	400
Approximate number of 300-lb. cans	210	350	700	1400
Daily approximate coal consumption in tons	3½	5	9½	18
Daily cost of coal at $3.50 per ton	$12.25	$17.50	$33.25	$63.00
Oil consumption daily of high economy oil engines, in gallons	80	120	225	430
Daily cost of oil at 3½c. per gal.	$2.80	$4.20	$7.88	$15.05
Saving in cost of fuel with oil engine drive	9.45	13.30	25.37	47.95
Total saving per year with 50% yearly load factor	$1701	$2,394	$4,567	$8,631
Approximate cost of installing aerating system	1200	1,800	3,300	6,000
Approximate cost of oil engine and accessories, including transmission	6500	8,500	15,000	28,000
Total cost of change	7700	10,300	18,300	34,000
Percentage of saving on investment	22	23	25	26

The horsepower of the engine is given approximately and is supposed to take care of the auxiliaries as well as the main unit. The auxiliaries can be arranged to be driven by belt. If motors are already in use, a generator can be installed with the engine to supply the current. If there are several old steam pumps and other steam-driven auxiliaries, it may pay to replace them altogether.

The coal consumption is based on less than 5 tons of ice per ton of coal for the 15-ton plant, and nearly 6 tons in the case of the 100-ton plant, with the consumption for the 25- and 50-ton plants graduating between the two. This should be a conservative basis and, if anything, favors the steam plant, as many plants fail to equal these figures.

The consumption of oil is based on the use of high-economy oil engines which will burn low-grade oils and operate continuously to fill the hard service demanded in ice-making plants. There are also oil engines somewhat less expensive, which will burn low-grade oils with poorer economy. While the fuel consumption may be higher, the saving in initial cost will be attractive in some cases, particularly where oil is very cheap and 25 to 50 per cent. more expense per day in the fuel item will be only a small amount.

One quality in the type and make of oil engine is absolutely essential and that is reliability. The continuous service required is possible only with a high-grade engine of heavy construction. Such designs have been developed in recent years, and the many thousand horsepower now in operation is sufficient to satisfy the most skeptical purchaser that this kind of motive power is perfectly reliable.

The price at 3½ cents per gallon is an average of the quotations in various sections of the United States. On the Atlantic seaboard Mexican crude oil is sold for about 3 cents per gallon on five-year contracts. Fuel oils are also sold in this section for about the same price. In the Middle States various fuel oils are sold for 3 or 4 cents per gallon. Texas, Louisiana and the vicinity provide cheap crude and fuel oils in the Southwest. Kansas and Wyoming oil fields are now supplying the local market at low prices. California furnishes crude oil at lower cost than any other state.

The figures given in the table for initial cost of installing the aërating system are approximate and cover air blower, core pump, air-distributing pipes and drop tubes, with something added for the work of installation and contingencies. The estimated cost for the oil engine or engines is supposed to cover all usual accessories such as water and exhaust piping, fuel-storage tank and foundation, also transmission.

Slight changes in the auxiliaries of the present plant may also be considered as part of the figures, although a careful estimate should be made for every plant to determine the cost of changing to oil-engine drive and if the investment will earn a sufficient return to justify the outlay.

Nothing is mentioned in the table about the saving of expense due to the elimination of the boiler plant. The labor required in the engine room will be the same as in a steam plant. The engineers should be good mechanics and possibly machinists, but no firemen will be needed. On the other hand, the labor necessary for properly operating the freezing system will be more. In the 25-ton plant two men day and night can handle the freezing and aërating system and also the ice storage. During the

night it will be possible to get along with one good man, provided the tank is equipped with a double hoist.

Two men day and night should be sufficient for a 50-ton plant, which has double hoists, although another man may be required for the ice storage, particularly during the day. In a 75-ton plant it will be necessary to have three men, and in the 100-ton plant twice as many men as in the 50-ton installation.

On the whole, the labor may be somewhat less with the oil-engine drive and raw-water system, but nothing has been figured in the table for this possible saving.

The approximate earning power of the additional investment seems to be in the neighborhood of 25 per cent. in all the sizes of plants for which figures are given, and it may be safely assumed that plants of any other capacity, except very small ones, will be improved to the same extent.

No consideration has been given to possible changes in the building, which may be necessary in those installations where the engine room is already crowded. There will probably be sufficient room in the average plant, with little or no building alteration, but should an extra expenditure be required for this purpose, the amount can be included in the initial cost when estimating the exact results in each particular plant.

Another question which frequently arises is the supply and price of oil. Not long ago the cost of fuel oil suffered a considerable increase. This was occasioned by an excessive demand owing to the widespread use of this fuel under boilers, in furnaces, kilns and other similar work. Since then the Mexican oil fields have been opened and an unlimited supply is now assured from that country. In fact, it has been possible for several months past to make five-year contracts for the delivery of Mexican crude oil to plants on or near the Atlantic seaboard and the Gulf States.

California, Kansas and Wyoming have opened new fields and the production in Texas and Louisiana is ample to supply fuel in that section at low prices. Furthermore, Central America, South America and the Northwest offer undeveloped oil country for the future supply.

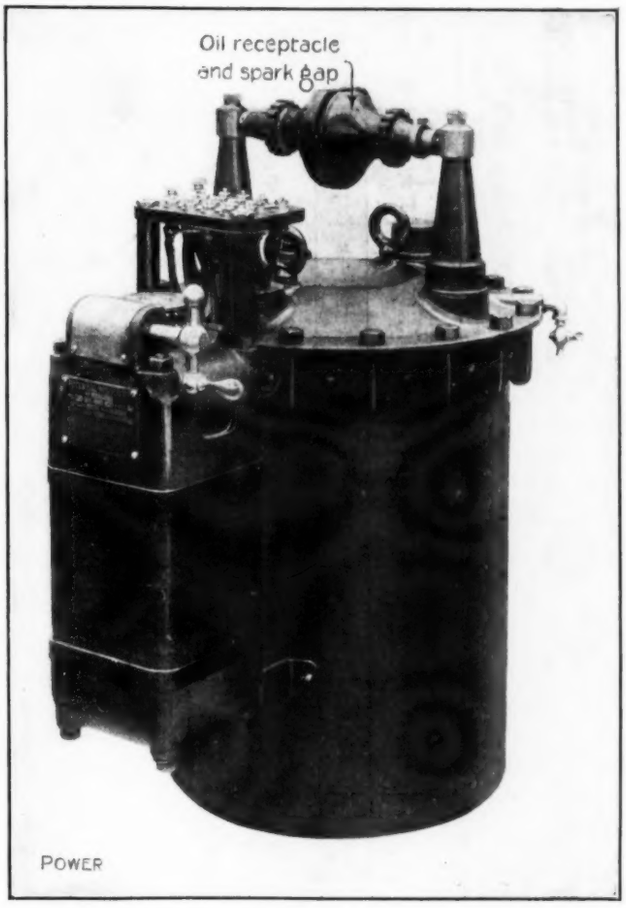
If the demand increases to an extraordinary extent, the price will increase. This will reduce the widespread use for boilers, kilns, etc., but it is unlikely that fuel or crude oil will become so high as to preclude the advantage and economy of oil engines.

Oil-Testing Set

With high-voltage, oil-insulated apparatus, in order to insure successful operation, it is necessary to maintain the dielectric strength of the oil at maximum value. For this purpose a testing set has recently been developed by the General Electric Co. for determining the dielectric strength of oil. The set consists of a testing transformer with an induction regulator for voltage control and an oil spark gap. All the parts are assembled and mounted so as to form one complete unit, which is compact and may be conveniently and quickly operated. The set is built for both 25 and 60 cycles.

The transformer has a rating of 3 kv.-a. at 30,000 volts, but may be operated at 10 per cent. above this. The high-voltage winding is equipped with a voltmeter coil for indicating directly the test voltage and the induction regulator allows a variation of voltage from zero to maximum. The regulator, as well as the transformer, is arranged for series-parallel connection, making the set suitable for use on 100- or 200-volt circuits. A dial is attached to the top of the rotor shaft of the regulator and is accurately graduated to give readings of the test voltage directly in kilovolts.

The oil is tested between flat metal disks, located inside the receptacle. One electrode is stationary, and the other has a micrometer adjustment with an adjustable zero index. This permits taking up readily any wear in the gap. The receptacle is designed so that it may be conveniently cleaned, and care has been taken that the quantity of oil required for tests is as small as is consistent with good results. It is estimated that three-quarters of a quart of oil is sufficient for one sample, allowing five tests on clean oil. The oil receptacle and spark gap are supported by the high-voltage terminals of the transformer and by merely turning the receptacle about its horizontal axis, the oil which has been tested, may be emptied.



Oil-Testing Set Complete

The receptacle and gap may also be easily removed from the supports, leaving the transformer free from high-potential testing of any kind up to 33,000 volts.

The weight of the 60-cycle set complete is 465 lb., height 30 in., length 24 in. and width 17½ in.; the weight of the 25-cycle set complete is 670 lb., height 32 in., length 26½ in. and width 20½ in.

Comparison of Standard Linear Units

Approximate Values in Common Fractions, Decimal Equivalents or Both

A	One Millim. Equals	One Centim. Equals	One Inch Equals	One Decim. Equals	One Foot Equals	One Yard Equals	One Meter Equals	One Rod Equals	One Chain Equals	One Hectom. Equals	One Furlong Equals	One Kilom. Equals	One Mile Equals	One Knot Equals	A
Millimeters	1	10	25.4	100	304.8	914.4	1000	5029.2	20116.8	100,000	201,168	1,000,000	1,609,344	1,853,256	Millimeters
Centimeters	1-10 0.1	1	2.54	10	30.48	91.44	100	502.9	2011.68	10,000	20,116.8	100,000	160,934	185,325	Centimeters
Inches	1-25 0.03937	4-10 0.3937	1	3.937	12	36	39.37	198	792	3937	7920	39,370	63,360	72,963	Inches
Decimeters	1-100 0.01	1-10 0.1	1-4 0.254	1	3.048	9.144	10	50.29	201.17	1000	2011.7	10,000	16,093	18,5[illegible]	Decimeters
Feet	1-300 0.00328	1-30 0.03281	1-12 0.08333	1-3 0.32808	1	3	3.2808	16.5	66	328.08	660	3280.8	5280	6080.2	Feet
Yards	1-900 0.00109	1-100 0.01094	1-36 0.0278	1-9 0.10936	1-3 0.33333	1	1.0936	5.5	22	109.36	220	1093.6	1760	2026.7	Yards
Meters	1-1000 0.001	1-100 0.01	1-40 0.0254	1-10 0.1	3-10 0.3048	9-10 0.9144	1	5.0292	20.116	100	201.17	1000	1609.3	1853.3	Meters
Rods	1-5000 0.0002	1-500 0.00199	1-200 0.00505	1-50 0.01988	2-33 0.06061	2-11 0.18182	1-5 0.19884	1	4	19.884	40	198.84	320	368.5	Rods
Chains	1-20,000 0.00005	1-2000 0.0005	1-800 0.00126	1-200 0.00497	1-66 0.01515	1-22 0.04545	1-20 0.04971	1-4 0.25	1	4.971	10	49.71	80	92.12	Chains
Hectometers	1-100,000 0.00001	1-10,000 0.0001	1-4000 0.000254	1-1000 0.001	3-1000 0.00305	1-110 0.00914	1-100 0.01	1-20 0.05029	1-5 0.20117	1	2.0117	10	16.093	18.53	Hectometers
Furlongs	1-200,000	1-20,000 0.00005	1-7700 0.00013	1-2000 0.0005	1-660 0.00152	1-220 0.00455	1-200 0.00497	1-40 0.025	1-10 0.1	1-2 0.4971	1	4.971	8	9.212	Furlongs
Kilometers	1-1,000,000	1-100,000 0.00001	1-40,000 0.000025	1-10,000 0.0001	3-10,000 0.00031	1-1100 0.00091	1-1000 0.001	1-200 0.00503	1-50 0.02012	1-10 0.1	1-5 0.20117	1	1.6093	1.853	Kilometers
Miles			1-63,000		1-5280	1-1760 0.00057	1-1600 0.00062	1-320 0.00313	1-80 0.0125	1-16 0.06214	1-8 0.125	5-8 0.62137	1	1.152	Miles
Knots (U. S.)			1-73,000		3-20,000 0.00016	1-2000 0.00049	1-1850 0.00054	1-370 0.00271	1-92 0.01085	1-19 0.05396	1-9 0.10855	7-13 0.53959	7-8 0.8684	1	Knots (U. S.)

NOTE—At the point where any vertical column crosses any horizontal column will be found the value of the unit named at the head of the vertical column expressed in terms of the unit named under A opposite the horizontal column. Thus, 1 meter = 1.0936 yards; 1 foot = 0.3048 meter.

A Private Plant Shows Large Saving

By Thomas Wilson

SYNOPSIS—Replacing central-station services, including lighting, power, heating and refrigeration, an isolated plant serving two office buildings effected a saving estimated at from $25,000 to $40,000 per year.

In one of our large cities there are two office buildings under the same management and of nearly the same size. One has been built for several years and has been served with central-station heat, light, power and some refrigeration for cooling the drinking water. The other, a new building, has a plant of its own, which will also serve the older building as soon as its contract expires. Operating-cost data on the two are available so that a comparison should be interesting.

Load in the New Building

The new building is equipped with 200 kw. in lamps, 29 motors for general use ranging from 3 to 60 hp. and nine elevator motors totaling 230 hp. Auxiliaries such as pumps and fans are driven either by motor or by steam, the proportion being about half and half. During the winter months the load runs close to 2200 kw.-hr. per day and in the warmer months, 1800 kw.-hr., so that the average for the year will be about 2000 kw.-hr. per 24-hr. day.

For heating there are 47,000 sq.ft. of direct radiation and for ventilation 16,000 sq.ft. of indirect surface. In zero weather this amount would require close to 450,000 lb. of steam per 24 hr. There would be available from the generating units, assuming a water rate of 40 lb. per kw.-hr. due to the fluctuating load caused by the elevators, 82,000 lb. and more from the steam pumps. It is thus evident that all of the exhaust can be used for heating and for hot water, and in the colder months, considerable live steam in addition is required. There is also a 30-ton absorption refrigerating plant which operates on the exhaust steam from the brine and aqua pumps.

Plant Equipment

The plant installed for the two buildings consists of four 350-hp. water-tube boilers equipped with underfeed stokers and forced draft. There are five 200-kw. units consisting of simple four-valve engines and three-wire, direct-current generators. For supplying the new building with steam it has been necessary to operate only one boiler. In the winter it is overloaded 40 per cent., during the spring it is run at rating and in the summer it is underloaded. When the older building is taken on the load will be nearly doubled, so that at least two boilers will be kept in service. Due to the heavy peaks imposed by the elevators, it is necessary to keep two generating units in operation, although one could carry the load the greater part of the time. It is evident that there is plenty of reserve capacity and that at present the plant is operating under unfavorable conditions.

Records from the Older Building

The older building has a total connected motor load of 426 hp., and the greater part of this, 310 hp., is required by three motors driving elevator pumps, as the elevators are of the hydraulic plunger type. There is a 25-hp. motor for a pump serving a freight lift, a total of 50 hp. in six motors driving ventilating fans and a number of small motors for other purposes besides the lighting for corridors, the power plant and for the tenants.

Last year, the total electrical supply for power, including power-plant and corridor lighting, which goes with the building, amounted to 463,022 kw.-hr. To the tenants, who are supplied individually by the power company, and additional 88,461 kw.-hr. was delivered for lighting. The total is 551,483 kw.-hr. per year, and dividing by 300, gives 1838 kw.-hr. per day of 24 hr. For an average the year around the load closely approximates that of the new building.

For heating, 38,000 sq.ft. of direct radiation has been provided, and steam is now supplied by the central station at a pressure of 5 lb. Hot-water service is required 12 months in the year. For 1913 a total of 22,700,000 lb. was used. As the total electrical load for the year was 551,483 kw.-hr., assuming an engine rate of 40 lb. per kw.-hr. due to the fluctuating load, there would be available

$$551{,}483 \times 40 \times 0.93 = 20{,}515{,}167 \ lb.$$

of exhaust steam. All of this would not be available in the heating season but the demand for live steam would be greatly reduced and the cost of heating would be only a small fraction of the present charge.

Probable Saving over Central-Station Service

Running under the present unfavorable load, the plant in the new building is producing steam for 20c. per 1000 lb. When the load of the older building is added it is believed that the cost will be reduced to 18c., as the same labor and overhead charges will be divided over a larger output and the plant should run more efficiently. The rate for steam charged by the central station is 37.5c. per 1000 lb., so that even if live steam were used entirely, service from the plant in the new building would save the older building 19½c. per 1000 lb., or $4426.50 for the year, out of a total of $8512.50 now paid the power company.

Of the 22,700,000 lb., assume that 20,000,000 lb. is required in the seven months of the heating season. As the electrical load is divided into 463,022 kw.-hr. for power and 88,461 kw.-hr. for lighting, and most of the power load is due to the elevators, the monthly demands for current will be practically uniform. Thus about seven-twelfths of the exhaust steam will be available for heating, which amounts to

$$\tfrac{7}{12} \times 20{,}515{,}167 = 11{,}967{,}181 \ lb.$$

Deducting this from 20,000,000 leaves a demand for live steam of 8,032,819 lb. At 18c. per 1000 lb., this would cost

$$8033 \times 0.18 = \$1445.94$$

The difference between this figure and the $8512.50 now paid the central-heating station represents an annual saving of $7066.56 on the heating alone.

The power load of 463,022 kw.-hr. per year is bought from the central station at a rate averaging 2.5c. per kw.-hr. The rate for the lighting load of 88,461 kw.-hr. divided among the tenants is 12c. per kw.-hr. for the first

three lighting units and 4c. thereafter. Dividing the total cost by the total consumption gives a rate of 9.2c.

With the combined load of the two buildings, it has been estimated that current can be produced at 1.7c. per kw.-hr., including both operating and fixed charges. On the power load of the older building it would be possible then to save 0.8c. per kw.-hr., or

$$0.008 \times 463{,}022 = \$3704.18$$

Assuming that the current for lighting is supplied to the tenants at cost, the total annual saving by supplying the older building from the private plant would be

$$\$7066.56 + \$3704.18 = \$10{,}770.74$$

This does not include the small saving that might be effected on refrigeration nor does it take into account the possible contingency of supplying the tenants with current at the same rate that they are now paying. In this event there would be

$$88{,}461 \times (0.092 - 0.017) = \$6634.58$$

to add to the profit side of the ledger, making a grand total per year of $17,405.32.

To have supplied the new building, with its slightly greater electrical load and more steam required for heating, with central-station service under aproximately the same conditions, the cost would have been more than double, so that the private plant means from $25,000 to $40,000 per year in the pocket of the management, depending upon the disposal of the lighting rates. The above figures would warrant an investment in power-plant machinery of $200,000 to $320,000 over the equipment that would be needed in the event of central-station current. It is small wonder that a private plant was installed.

Determination of Engine Clearance

By H. F. Godeke

Engine clearance has been variously defined, but for technical purposes there can be but one definition: It is the volume in the cylinder that is not swept through by the piston and includes the volume of the ports and that of the drips and indicator piping up to the cocks, for the particular end under consideration. Clearance should never be confused with clearance length or clearance distance; these mean the distance in inches between the piston and the cylinder head when the engine is on dead center. Clearance is volume, not a linear dimension. The volume represented by this distance is a part of the clearance, but it also includes the other parts mentioned.

Clearance is often expressed in percentage. This percent. is the ratio of the clearance volume for one end to the volume swept through on that same end. Thus for the engine crank end, it is the ratio (expressed in per cent.) of the clearance volume to the crank-end piston displacement which, of course, is corrected for the piston rod. Clearance is seldom the same for the two ends of the cylinder, therefore it should be determined for each end separately. This is found by several methods, viz., measurement of openings and computation of volumes, filling the spaces with a plastic substance, such as putty, and then getting the volume by the displacement of an equal volume of water or other liquid, whose density is known, and again by filling the voids with a liquid such as water or oil. The last, the volumetric method, is probably the most practical as well as the most accurate.

The engine should be put on the center and the clearance volume filled through the indicator connection, the weight of the liquid necessary to fill the space being determined by the difference in weight of the vessel and the contents before and after filling. The engine can then be turned over until the crosshead has traveled one inch from the dead-center and the weight of the liquid required to fill the additional inch of the cylinder be determined as before.

If W is the weight necessary to fill the clearance volume;
W' the weight necessary to fill the additional inch, and
L the length of the stroke in inches, then,

$$\textit{the percentage of clearance} = \frac{W \times 100}{W' \times L}$$

Care must be taken to see that there is no leakage and that no air is pocketed in the cylinder. In a fairly tight cylinder, with the valve seat covered by a sheet of packing under the valve and the inside of the cylinder well lubricated, water may be used. Generally, oil is much more satisfactory, the writer having found cylinders which could not be made tight against water to hold oil satisfactorily.

Methods of correction have been offered in case of leakage, the most common being to take the time required for filling the clearance volume and then, after the space has been filled, to keep it filled for a definite time, say one minute. Since the leakage is zero, when starting to fill and maximum when the space is filled, the average rate of leakage is then assumed to be half of that when filled. This average rate is multiplied by the time required to fill originally and then subtracted from the weight needed to fill the space, thus giving the net amount necessary to fill the clearance.

The writer objects to this method because he does not believe the leakage follows a straight line curve. There are two factors which govern leakage, viz., head and opening, both of which increase as the space becomes filled. Necessarily the curve must be a second-degree curve, so that the average leakage rate during the time of filling the cylinder will be less than half the maximum rate. The one solution then is to use some liquid heavy enough to prevent leakage.

Some time ago the writer wanted to know the clearance of the cylinders of a cross-compound, steam-driven air compressor and the makers were unable to give any data. The clearance could not be had by measurement without taking the entire machine apart; neither could the volumetric method be used directly, because the indicator connections were on the side instead of on the top of the cylinder. The indicator piping was removed and a nipple, with a piece of ¾-in. rubber hose long enough to reach above the top of the cylinder, connected to the indicator tap. A small steel tube was put down through the hose and so bent as to reach the top of the cylinder, the purpose being to draw the air from the top of the cylinder as the liquid was poured in.

With the engine on dead center the piston would not allow the tube to enter, so the engine was turned over until the piston was ¼ in. from the end of its travel, the necessary correction for this additional volume being made later. Water was first tried as a liquid, but it was impossible to fill the volume, because of leaks. Engine oil was used with no leakage whatever. Proceeding as stated, the volume of the space was obtained. The following corrections then had to be made: First, the volume occupied by the steel tube had to be added to that as determined, the volume of the hose and nipple had to be subtracted and that of the indicator piping up to the indicator cock had to be added. This method is simple and gives results that are quite satisfactory.

Home-Made Gas Analyzer

By E. J. Saxe

No instrument is of greater value to the operating engineer than the gas analyzer. In no other way can he learn how to improve the furnace performance with the same certainty. As the cost of the cheapest is sometimes prohibitive, it is here intended to show how anyone can, with little trouble and at small expense, make an analyzer that, while lacking the finish of the factory-made instrument, will give good results, which is the main point.

The writer at one time carried an Orsat appartus, but in extended traveling frequently broke bottles which could not be replaced in a small town. To get them from Chicago was expensive and the time lost was a matter of still more importance. Finally, a rig was devised of material to be had at any drug store. A similar one may be made by anyone who will procure from a dealer of such instruments a 100-cubic centimeter burette having a 50-cubic centimeter bulb (as the tube and the case are shorter than otherwise). Fig. 1 shows the case, which can be made of any material to suit individual taste. With the burette purchase a glass three-way cock, six feet of small glass tubing, six feet of ¼-in. rubber tubing, and two pinch clamps; this will cost about $5.

From a druggist get three 6-ounce bottles, and an ounce of half spirits of camphor and half turpentine, break off the tip of a small round file, wet it in the mixture and drill a hole in each bottle near the bottom. A breast drill can be used, or the file may be revolved with the fingers; drilling a hole in glass this way is not difficult. When the file end gets dull, break off a small piece and it will again cut rapidly. File the hole smooth and round and of such size that the rubber tube will fit tightly and be water-tight. Connect the two bottles as shown in Fig. 2, and fill one of them with the glass tubes, broken to lengths to go inside (shown in the shaded bottle). This is the absorption bottle. The tubing is to provide a larger wetted surface, and consequently a more rapid absorption of the gas. The other bottle is to hold the solution when it is driven out of the first bottle by the gas to be tested.

In this first bottle place a rubber stopper, having a glass tube through it. It should project about a half inch on each side of the stopper to attach the rubber tube on the outside and the lower end serves as a gage for the solution when in use.

If it is desired to test for CO and O, three such pairs of bottles must be made and a different solution used in each, but for ordinary use the CO_2 test is all that is needed and the engineer can generally tell whether a small per cent. is due to too much or too little air.

Join the burette and absorption bottle with the three-way cock with rubber tubing as shown, and connect the other bottle with the bottom of the burette by 18 inches of the rubber tube for a leveling bottle. Fill the absorption bottles half full of a solution of caustic potash and water as strong as can be made. Then proceed as follows: Fill the leveling bottle with water, open the three-way cock to the atmosphere and raise the leveling bottle to fill the burette with water. Next turn the three-way cock to connect to the caustic bottle and lower the leveling bottle until sufficient water has run out of the burette to raise the caustic solution in the first bottle to a point where it just touches the glass tube in the cork. Turn the three-way cock to cut off from the caustic, open to the atmosphere and again fill the burette with water by raising the leveling bottle.

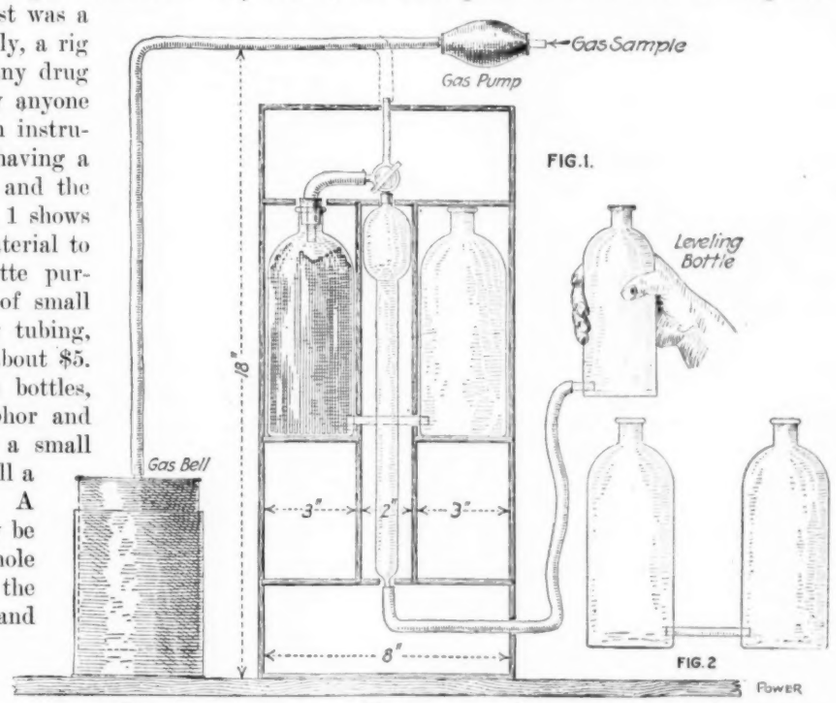


Fig. 1. Assembled Unit Fig. 2. Bottles Connected

You now have 100 cubic centimeters of water in the burette, and the first obsorption bottle is full of the caustic and the other bottle is nearly empty. Now all is ready for the gas sample. Make a gas bell out of two tin cans, one of which will easily slip inside of the other. In the bottom of the smaller one solder a short spout to which

to attach the rubber tube and fill the larger can with water. Put the smaller into it bottom up, so that it will be completely filled with water and all air excluded. Put a piece of quarter-inch gas pipe through the boiler setting at the point where you wish to obtain the sample, taking care to avoid dead spaces and corners. To this pipe attach the tube and bulb of a cheap syringe, which answers as a gas pump, and pump a sample of gas into the gas bell. It is well to pump some gas through the bell to make sure that all air in the pipe and tube has been expelled.

Having obtained the sample, next connect the gas bell to the burette, and draw the water down to the zero mark (by lowering the leveling bottle). You have now drawn off 100 cubic centimeters of water and the gas has taken its place.

Turn the three-way just enough to shut off from the atmosphere without opening to the caustic and disconnect from the gas bell; open the three-way to the atmosphere for an instant. This will relieve any pressure above the atmosphere that may be on the gas. Then turn the three-way to connect the burette with the caustic bottle. Raise the leveling bottle so that the water will drive the gas over into the caustic bottle, then lower the leveling bottle and draw the gas back into the burette. Repeat this operation two or three times. Now, finally draw the gas back into the burette until the caustic just touches the glass tube in the cork, as in the beginning, and turn the three-way to close from both atmosphere and caustic. Then raise and lower the leveling bottle until a place is found where the gas is free from compression or expansion, and the amount that the water now stands above zero on the graduated scale is the per cent. of CO_2 absorbed.* With a little practice, these tests can be made rapidly.

A sample of gas from just back of the bridge wall under the boiler should show 12 to 16 per cent. If it does not, look at the fire and see that the grates are all covered, i.e., no holes in the fire. Then try different thicknesses until this per cent. is obtained. Next take a sample at the back end of the combustion chamber or at the uptake. If the CO_2 is less the farther you get from the fire, it is due to air infiltration and the obvious remedy is to get after the cracks.

Just what this air leakage means can be told by the following table:

% CO_2	2	3	4	5	6	7	8	9	10	11	12	13	14
% Loss	90	60	45	36	30	26	23	20	18	16	15	14	13
% Efficiency	10	40	55	64	70	74	77	80	82	84	85	86	87

After this a draft gage will be needed. With a blow torch, heat a piece of glass tube 8 inches long to a cherry red and bend it in the form of a hairpin. Fasten it to a board and mark off a scale of inches divided in tenths on a card, and the difference in the water level in the two legs is an indication of the vacuum. Try different draft pressures and after observing the effect on the CO_2 readings, a decided saving in coal will be noted.

As the boss should know what has been done, make him a neat looking statement of what all this means in dollars and cents per year. He will be interested, though he may not seem to be, and it will surely have its effect in time.

*The illustration should show the graduations on the burette tube from zero near the bottom to 50 at the top. The pinch clamps referred to are for use on the rubber tubing to stop the flow of gas.

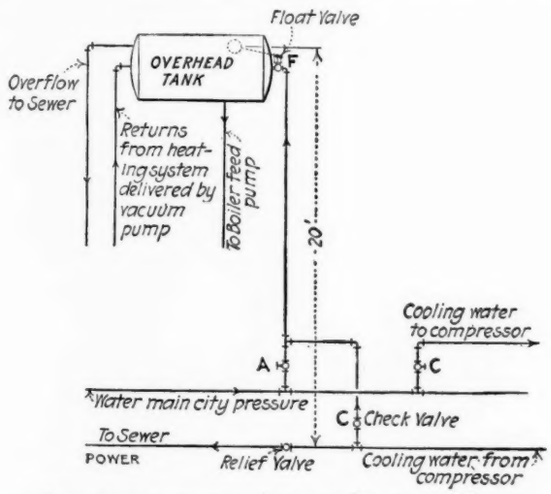
Saving Cooling Water

By T. W. Reynolds

The sketch shows an arrangement of piping whereby the cooling or jacket water from a compressor was saved and delivered through a float valve into an overhead receiver from a heating system.

Only a small quantity of makeup water for boiler purposes was required, therefore the water from the compressor could not be continuously discharged into the receiver without wasting part of the heat of the return water by the overflow from the receiver discharged to the sewer.

To avoid wasting this cooling water when required as makeup, an arrangement was made as shown, whereby it is discharged into the receiver when the float valve *F* is open. When this valve is closed the jacket water, which is at city pressure, is automatically discharged to the sewer through the relief valve.



Arrangement for Saving Cooling Water

When the compressor is not running, valve *A* is opened, admitting a direct supply of city water to the receiver.

The relief valve should be so adjusted that it will open to the sewer at slightly over 10-lb. pressure. This will allow for the static head of 20 ft. to the tank. Otherwise the water would pass through the line of least resistance, i.e., through the relief valve to the sewer, rather than raise itself to the elevated tank.

Knurled Pipe-Cutter Wheels

The Nye Tool & Machine Co., Chicago, Ill., has recently developed a pipe cutter fitted with a knurled-edge cutter wheel in place of the usual plain, sharp-edge disk wheel. The teeth are knurled diagonally and remove metal during the cutting process instead of upsetting it, as is done by the ordinary disk wheel. Friction is, therefore, reduced and large pipe can be cut with less effort. The knurled wheels are made in sizes and styles to fit any regular make of holder on the market.

Draft Value—Each quality of fuel used requires a special draft value. For run-of-mine bituminous coals an average of 0.01 in. of water is allowed for each pound of coal fired per hour. Thus two 300-hp. boilers having a total of 106 sq.ft. of grate area and burning 20 lb. of fuel per sq.ft. per hour would require a draft of (20 × 0.01 in.) = 0.2 in. The draft actually used will generally be from two to five times that really required.

Editorials

No Place for the Central Station

The central station has a legitimate field to which it can supply electrical energy at a cost lower than it could be produced individually by its customers. But a large office building requiring steam for heating, and perhaps refrigeration, is far removed from this class, as with an uptodate isolated plant and efficient management the various services can be supplied at a cost lower than any legitimate charge made by the central station.

It is true that the cost of generating current in the central station is usually less than in a small isolated plant, but the cost of distribution and the overhead charges attached to the former are so heavy as to more than wipe out any advantage gained in the engine room. In obtaining large business it is quite customary for the central station to omit all, or the greater part, of these last two items from the charge to the consumer and make it up by exorbitant rates to the small customer, but even then the steam which must be generated for heating presents an insurmountable obstacle.

Why then are so many buildings purchasing current? If the truth were known, many of them are controlled through interlocking financial interests. Then again there are owners who will listen to plausible solicitors and sign contracts with but little knowledge of what they are doing. The combined cost of electrical service and heating, however, soon presents evidence which is undisputable.

A noteworthy example of an isolated plant which has effected a large saving is cited on other pages of this issue. The names and locations of the buildings are withheld due to a request by the owner, but the facts and results obtained are presented. The results are specially interesting as there are two buildings, of nearly the same size and requirements, one supplied with central-station service and the other containing an isolated plant, although this condition will exist only until the central-station contract for the older building expires.

With the older building the owner made the common mistake of installing central-station service, not only for lighting and power but for heating and some refrigeration as well. Paying the bills for these different services was an excellent schooling, and when the new building went up a private plant was installed.

For central-station charges on the loads carried, the rates were not excessive, thirty-seven and one-half cents per thousand pounds of steam and two and one-half cents per kilowatt-hour, yet a large saving was effected. The private plant is capable of producing high-pressure steam for eighteen cents per thousand pounds, and by using the exhaust from the generating units, the demand for live steam is greatly reduced. In fact, the annual saving on this one item in the older building amounted to more than seven thousand dollars. Including interest, depreciation and all operating charges, and making no allowances for the utilization of exhaust steam, current can be generated for 1.7 cents per kilowatt-hour, as compared to the 2.5 cents charged by the central station.

To the saving in the older building this difference added nearly four thousand dollars, and sixty-six hundred more if the private plant furnished current to the tenants at the price made by the central station. Neglecting the last item, the estimated saving in the older building totals nearly eleven thousand dollars. It should be more in the new building even after allowing for some decrease in rate due to the larger demand. A saving of twenty-five thousand dollars per year on the two buildings is a conservative estimate.

Many office-building plants of various sizes in the country are making good, and their records would no doubt be available to those really interested. In these days dividends from office structures are not so large as to warrant throwing away several thousand dollars per year. Whether to buy or make current is a question worth investigating, for generally the building owner will save money by installing an isolated plant.

Industrial Education Again

We commented on this subject editorially in our issue of July 28, and are minded to mention it again because of two references to it in this number. Mr. Dixon in his letter, "Industrial Education—a Warning and a Hint," on p. 689, says many things in which we concur, howbeit his criticism is a bit sweeping and in parts rather cynical.

Incidentally, we take exception to his characterization of "safety-first" propaganda as hypocritical. While unquestionably the movement is a fad with some, and there are those identified with it for selfish purposes of their own publicity, the fact remains that it has its origin in a real need and its value is so important that it deserves emphasis by whatever means may happen to be employed. We have added our comments whenever they seemed called for and shall continue so to do while those responsible for public welfare and safety persist in evidencing a disposition to be careless or reckless.

To return to the subject in hand, we endorse the work recounted under "Engineering Affairs," p. 696, undertaken at Pratt Institute to train practical mechanics as teachers of their several trades. This course approaches the problem in so eminently logical a manner that we believe it will have the approval of all interested in securing the best results from industrial education.

Without detracting from the advantages of the study of pedagogy to all who enter the instructing profession, we submit that, at least so far as trade school work is concerned, it is easier to impart enough of the teaching art to those already experienced in the mechanic arts for them to become efficient trade teachers than to supply the lack of practical shop or power-plant experience to those whose main qualification is a knowledge of educational methods. We look for a large success for the course initiated at Pratt Institute and hope to see the instructing

staff of industrial schools mainly recruited from the ranks of men who have received such training.

The main theme, as we read it, in Mr. Dixon's argument is that the mere earning of a living should not be the whole purpose of educational training; naturally, industrial schools form the only class of educational institutions that need this warning. A basic idea of such schools is to eliminate waste time in unnecessary studies, but if the instructors are guided only by the motive of equipping their students to earn a living, they err, in Mr. Dixon's judgment. However, is it not likely that, if the teachers are drawn from the field in which they are teaching others to serve, they will sense all the needs of the workers in that field sufficiently not to exclude the training which will enable them to derive the greatest enjoyment and satisfaction in their chosen sphere of activity?

Granted that the country needs not simply workers but thinkers and good citizens, the problem resolves itself into the difficult one of deciding how far the industrial schools should go in endeavoring to inculcate the broader principles of useful citizenship into their students. If they are at present leaving too much to the chance that the individual student will develop properly by instinct, home influence, or contact with his fellows in the broad school of life, what can they do to remedy this defect? The best suggestion we can offer is that the instructors be carefully selected for their professional success and general integrity. The rest can be left to their wisdom to adopt the best instructing methods and to their example to inspire their students.

A Gag on a Safety Valve

As stated on page 695, the lever of a safety valve on a high-pressure boiler was held down by a prop under the sidewalk. It seems incredible that such a thing should be done in the heart of a city, on a large boiler located directly under the sidewalk around a hotel, on the corner of two busy thoroughfares. Overloaded safety valves in out-of-the-way places probably do exist, but in a city and a plant in charge of licensed engineers, day and night, a hotel full of guests, with café and dining room patronized by hundreds and the sidewalks traversed by thousands daily, it is almost beyond belief.

Aside from the gag on the safety valve, there was but one relief valve attached to the boiler. This circumstance emphasizes the need of an auxiliary spring loaded valve, which can be locked when properly set so that it cannot be tampered with. Such a valve should be required on all boilers (as it is in several states and some provinces in Canada). There was no convenience for lifting the lever of the valve and, as its location and surroundings made it almost inaccessible, it is likely this was seldom done. It may be easily credited that the daily test as well as allowing the valve to blow from over-pressure were objected to on account of the noise and other annoyances. Was the gag put on for that reason?

Then again, this boiler was not equipped with a fusible plug to give warning in case of low water. Surely such an inexpensive safeguard should not have been omitted.

The method of putting in the new tubes is seriously questioned. The previous set had been rolled several times during its time of service and the holes in the tube sheet were considerably enlarged as a result. If the holes were stretched more on the inner than on the outer side of the sheet, the staying effect of the tubes would be almost nil. This, together with the fact that the new tubes were not beaded over or even flared on the outside, would cause the head to receive the strain unaided. The total load on a head of such diameter might easily be beyond the resistance of the unsupported sheet.

Specific instructions as to the proper method of expanding tubes into the headers of water-tube boilers, and which are equally applicable to other types, appeared on page 245 of the Aug. 18 issue, written by E. H. Wells.

The use of shims, especially thick iron ones, has more of the look of a patch job to make undersized tubes do than first-class fitting. As a matter of fact, they are often used, but the tubes should be flared or beaded over them.

Local regulations should certainly be more stringent and more inspectors should be added to the boiler squad to make closer supervision possible. Don't forget that thorough and efficient examinations and inspections before accidents bring better results than the same work after an accident.

The War and the Fair

Commend us to the optimist every time. We have to admire the chap who faces a dismal outlook with a grin even if it is forced. So we say "Hats off!" to the publicity department of the Panama-Pacific Exposition for making a statement like this:

> There is nothing in the present situation that seems likely to affect seriously the success of the exposition.

The best part of it is that after so bold a declaration they still have the courage to back it up with the following reasoning; which certainly does "listen well":

> Any possible loss of exhibits from countries involved in war, if it occurs, will be balanced by an increase from other directions. The effect on attendance, if any, is likely to be favorable rather than otherwise, what is lost in attendance from Europe being ten times compensated for by Americans coming here instead of going to Europe.

Further, they claim that the war will turn "hundreds of thousands" of tourists from North and South America to the exposition instead of to Europe. An official says:

> The war in Europe will offer a great opportunity to American manufacturers. One of the contending European nations has controlled 70 per cent. of the South American trade. This war will force that trade upon us and force Latin-Americans to visit this country. It has been impossible for the American manufacturers to invade the commercial fields held by Great Britain and Germany in Latin America.

And he goes on to say that under the conditions the English and German nations will

> find it necessary to make a strenuous effort at the exposition to retain their trade, which previous to the crisis they considered secure, and, above all, the exposition will be the beneficiary of the unprecedented prosperity of the Middle West resulting from their bumper crops and war prices.

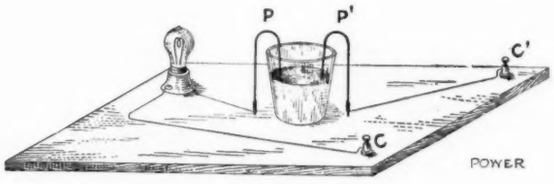
Enthusiasm and loss of heart are both infectious, so a gloomy prospect may be improved by such talk, and surely will be aggravated by the other kind. Therefore, those who insist on believing that the war will make prices high so that those in moderate circumstances will have to economize and forego unnecessary travel, especially to world's fairs where nothing is cheap, or who think that nations at war have enough of a job on their hands and no time or money to devote to preparing exhibits, should keep such thoughts to themselves.

Let us show the world that we can make a success of the Fair in spite of the unfavorable conditions.

Correspondence

Determining Polarity

The sketch shows a simple means of detecting polarity in a direct-current circuit. It consists of a wooden board upon which is mounted a 16-cp. lamp and socket, in circuit with two terminals C and C' and two pieces of



Simple Means of Determining Polarity

fusible wire P and P' which project into a glass containing water with 8 or 10 drops of sulphuric acid.

When the terminal posts have been connected to the circuit the lamp will light and bubbles will appear in the glass. Within a short time, one of the leads in the water will become brown and the other a bright gray. The former will denote the positive and the latter the negative wire.

F. P. Ampudia.

New York City.

Pump-Motor Troubles

A three-stage pump, driven by a compound, direct-current, variable-speed motor, handling drainage water in a mine, gave trouble by taking too much current and tripping the circuit-breaker in the power house when the speed was increased to give the required head. At first it was thought to be due to stoppage at the inlet of the pump. Accordingly, the casing was opened several times and the parts examined, but they were free and properly assembled.

The machine was a mile from the power house, and had over 300 ft. of lift. The motor was started in the usual manner with full field, the speed being increased by weakening the shunt field until the pump began to deliver water. The slight rise in speed necessary to increase the flow resulted in a heavy increase in current, causing the circuit-breaker to go out.

Several trials convinced me that the trouble was due to a wrong series field connection, for when the motor was brought up to speed by weakening the shunt field, the series field became stronger by the increased current until at a certain load it overcame the shunt field, and, being in the opposite direction, tended to reverse rotation with the results as noted. Accordingly, the series field connections were reversed, after which the machine was put into service and took only normal load current.

In another instance a small three-phase motor driving a centrifugal pump heated excessively when first put in service. An ammeter in the line showed overload current, and, believing the trouble to be caused by over capacity of the pump on account of the nature of the liquid handled, the piping was changed so that a test for head and capacity could be made. This showed the motor to be a little overloaded, but not enough to account for the excessive current.

A wattmeter connected in the lines near the motor showed that the trouble was due to the auto-transformer used in starting. All three lines were closed when in the starting position, but in the running position one line was open because of a broken contact finger. This was repaired and the motor operated satisfactorily.

William Salt.

Trenton, N. J.

Gaskets for Plugs for Compressor Valves

We are having trouble in keeping the plugs tight on the valve bonnets of an ammonia compressor. Lead gaskets have been tried made of one part bismuth, one part tin and twenty-five parts lead, but these were too soft and would not hold; they seemed to melt away.

As the machine is old-style, we do not know what kind of gaskets were used originally. Recently the valves were reseated and the repair man did not use the correct gasket material when he put the plugs on. Will readers please advise what material we should use for these gaskets?

Christian L. Herr.

Lancaster, Penn.

Simplifying Reports of Boiler Tests

A report of a boiler test should interest any business man who has, or expects to have, a boiler. If we address a report of any kind to an audience, we use the language of that audience rather than our own; we address the English in English, the French in French, the Chinese in Chinese. Therefore, we should address a report to the public in language used or understood by the public.

Many boiler plants are under the management of busy and brainy men, who are not, however, chemists, physicists or engineers. Such men become lost amid the confusion of unnecessary technical phrases, fail to distinguish between what are apparently slight shades of expression, and finally give up all idea of understanding reports which, though meant for them, are written in an unfamiliar language. Hence it is often impossible for them to compare one boiler test with another and arrive at any satisfactory conclusion.

A boiler-test report will contain one or all of the following expressions:

1. Actual evaporation per pound of coal as fired.
2. Actual evaporation per pound of dry coal.
3. Actual evaporation per pound of combustible, mechanically obtained.

4. Actual evaporation per pound of combustible, chemically obtained.
5. Equivalent evaporation per pound of coal as fired.
6. Equivalent evaporation per pound of dry coal.
7. Equivalent evaporation per pound of combustible, mechanically obtained.
8. Equivalent evaporation per pound of combustible, chemically obtained.

Is it any wonder that the business man throws up his hands in despair? Eight expressions, all much alike and all different! Can we blame him if he is prone to consider his engineering brother as pedantic and fond of splitting hairs?

The expression, "a pound of coal," is used by the engineering fraternity as though coal were a definite and fixed compound of unvarying mixture and heat value. All of these things coal is not, and neither is combustible, so that after using such expressions we, of the engineering profession, clear up our own conscience by other expressions, which, while clear to us, are equally maddening to our clients. What does the "efficiency of boiler, furnace, and grate" mean to them, and what difference can they see between that and the "efficiency of boiler and furnace?"

The Bureau of Mines, Bulletin 22, gives the analyses of coals of the United States, the heat values ranging from 5000 to 15,000 B.t.u. per pound. This shows that "a pound's a pound the world around" does not apply to coal, as the burning of a pound of one grade will make as much steam as the burning of three pounds of another grade.

When a certain amount of coal is fed onto the grates, the ash, slate and other refuse, and such of the coal as falls through the grates, are not burned. This unburned material may all be weighed and the weight of the burned material thus ascertained. This actually burned material is called the "combustible." A pound of it, however, will have as wide a variation in heat value as the coal itself. A pound of "combustible" is therefore a meaningless term.

It is true that the engineer makes a report of two kinds of efficiency, one based upon the heat value of a pound of "dry coal," the other upon that of a pound of "combustible." The theory is a beautiful idea that all the weight of coal fired except the moisture and the residue which has fallen through the grates, passes off from the grates in a combustible form and that it is the duty of the furnace and boiler to utilize as much as possible. The grate itself is exonorated from responsibility in connection with the utilization of this "combustible" and the efficiency which is based upon it is called by engineers "the efficiency of furnace and boiler." The other efficiency, which is based upon the heat value of the "dry coal," is arrived at by considering that it is the duty of the three essential parts (grate, furnace and boiler) to utilize as much as possible of the potential heat furnished them as coal.

These two distinctions are unnatural and misleading. The grate cannot thus be irrationally separated from the furnace and boiler. The ratio of the potential heat in a pound of dry coal to the heat actually developed per pound of dry coal is not unequal to the ratio of the potential heat in a pound of coal as fed, to the heat actually developed per pound of coal as fired. Why, then, refer to dry coal?

If coal drops through the grates unburned, or only partially burned, it may be due more to the construction of the furnace over the grates than to the grates themselves. On the other hand, volatile matter may be separated from the fuel and be included as part of the combustible for which furnace and boiler must account, whereas it will really pass up the stack unburned on account of inferior grate construction. Or the entire boiler may be cooled off on account of the grates allowing too much air to enter. It is clear then that the efficiency of the grate cannot be independently established and that any report of efficiency must include it, as well as the large factor of the efficiency of the fireman, who may handle most efficient apparatus inefficiently or *vice versa.*

In considering or comparing any boiler efficiencies, it is well to remember that no two boiler tests can be compared truly and absolutely one with the other on account of this human element, and that behind extremely high efficiencies there may stand skillful firemen.

Another troublesome expression to the ordinary business man is "evaporation from and at 212 degrees." He can conceive that more heat is required if the water is fed in a colder state and that less will be required if the temperature, or pressure, of the steam is reduced. He can conceive therefore that a certain feed and a certain steam temperature may be used as a "standard" in order to compare one evaporation, or production, of steam to another.

To sum up, the use of expressions admittedly meaningless, variable, or difficult for the laity to comprehend, is a needless impediment. Evaporation "from and at 212 deg. F." may be expressed as "standard evaporation," the meaning of which any ordinary man will grasp. In like manner, true comparison of one test with another requires a "standard fuel." Say, for instance, any weight of any fuel containing 10,000 B.t.u. comprises a pound of "standard fuel." Bearing these ideas in mind, the report of a boiler test can be greatly clarified and condensed. Any report of moisture, ash, refuse or combustible is discarded as these factors are automatically cared for by the use of a "standard fuel." Conditions of ash, slate, moisture, etc., are elements of a report of a fuel test, anyway, rather than a boiler test.

While the adoption of these views would result in a "simplified report of boiler tests," as given herewith, one readily understood by engineers and laymen alike, yet the essential commercial results which the business man wishes to know comprise only the efficiency of the boiler and the capacity of the boiler while showing that efficiency; or *vice versa,* the capacity of the boiler and resulting efficiency. For fuels of a similar nature, these results are independent of every condition except the skill of the fireman; and by these results alone can one equipment and operator be compared to another equipment and operator. Efficiency should be based only upon the coal as fired, or should express the relation of output to input.

If I were a business man, I would eliminate the noncommercial items of a boiler report entirely and would wish to know only four things about a boiler test:

1. The kind of fuel used.
2. The skill of the fireman.
3. The capacity during test.
4. The efficiency during test.

I should want tests made, to secure as great a capacity as possible and to know at what per cent. of rating the best

efficiency was secured and what overload I could carry.

Below is given a simplified report for a boiler test, one containing all facts essential to the engineers, also a condensed commercial report containing facts essential to the business man:

SIMPLIFIED REPORT OF BOILER TESTS

(10,000 B.t.u. taken as a pound of "Standard Fuel"; 970.4 B.t.u. taken as a pound of "Standard Evaporation.")

General:
1. Test to determine.....
2. Test conducted by.....
3. Date of test.....
4. Duration of test.....

Fuel:
5. Kind of coal.....
6. Name of mine.....
7. Size of coal .....
8. Name of fireman.....

Boiler:
9. Kind of boiler.....
10. Water heating surface.....
11. Superheating surface.....

Furnace:
12. Kind of furnace.....
13. Height of furnace.....
14. Length from rear end of grates to heating surface....

Grate:
15. Kind of grate.....
16. Area of grate.....
17. Per cent. of air space in grate surface.....

Average Observations:
18. Steam pressure by gage.....
19. Temperature of feed water entering boiler.....
20. Temperature of gases leaving boiler.....
21. Force of draft between damper and boiler.....
22. Force of draft in furnace.....
23. Quality of steam.....

Total Quantities:
24. Weight of coal as fired.....
25. B.t.u. per pound.....
26. Weight of water fed to boiler.....
27. Weight of water actually evaporated.....

Hourly Quantities, Actual:
28. Coal fired per hour.....
29. Coal fired per hour per sq.ft. of grate.....
30. Water actually evaporated per hour.....

Hourly Quantities, Equivalent or Standard:
31. "Standard" fuel per hour.....
32. "Standard" fuel per hour per sq.ft. of grate.....
33. "Standard" evaporation per hour.....
34. "Standard" evaporation per hour per sq.ft. of heating surface .....

Capacity:
35. Rated evaporation per hr. per sq.ft. of heating surface.
36. Actual evaporation per hr. per sq.ft. of heating surface.
37. Rated horsepower.....
38. Actual horsepower.....

Efficiency:
39. Efficiency, ratio of total heat output to total heat input.

CONDENSED COMMERCIAL REPORT OF BOILER TEST

1. Test to determine.....
2. Conducted by.....
3. Kind of equipment (boiler, furnace, and grate).....
4. Kind of coal (class, mine, size).....
5. Kind of fireman (name and skill).....
6. Actual horsepower in per cent. of rated.....
7. Efficiency .....

EGBERT R. MORRISON.

Chicago, Ill.

Industrial Education--A Warning and a Hint

A large part of present education has little reference to life as it is today, either in substance or methods. Yet education should be preparation for life. Professor Dewey, one of the foremost apostles of the new education, says: "It is its business to select whatever is relevant to the most effective carrying on of life's functions, and to arrange what is selected; not on the basis of some outside pattern, but with reference to facilitating the complete practical performance of all the activities possible to an organic being." Let us nail that down. "All the activities possible to an organic being."

Herbert Spencer cataloged these activities as five: Self-preservation; earning a livelihood; society; civic duty; parenthood. The first we may leave to "chambers of commerce" and their hypocritical propaganda of "safety-first." The last is the most important of all. The fourth needs more emphasis than it has had. The second has received too much. Why need we worry about earning a living? Ford's floor sweepers get $1500 a year. It is not difficult to earn that much. The trouble, for most of us, comes in getting it. As Mr. Post used to tell us, "There is a reason"; and though it would seem fitting that the schools might teach us that reason, it is hardly probable that they will until the fact becomes historic.

This line of argument has an economic trend that it may be out of place to pursue here. It should, however, be kept in mind whenever this question is discussed. It is introduced here because so many writers seem to proceed on the assumption not merely that we need a training to enable us to earn a living, but that this sort of training is the whole work of education. It is only natural that the capitalist should make this mistake; it is to his selfish economic interest. The engineer has no such excuse. He should approach the matter in a broad way. Prof. Frank T. Carlton says: "The United States stands at the parting of the educational ways. Is education to be primarily for the purpose of training workers or young men and women? Will the demands of 'big business' or the demands for good citizenship and racial efficiency dominate? Here is the greatest danger in present education."

Mr. Fish, in a recent number of POWER, cites some efforts now being made in certain trade schools to train boys to be operating engineers. It is one of the great faults of these trade schools that they fall into the grave mistake above mentioned. In this matter, it seems to me, they have over-reached themselves. I am a firm believer in education for the engineer, not that it may bring him more money, for it is likely that the same effort in other lines would bring more substantial results, but because it tends to safety, efficiency, and that pleasure in work without which life is hardly worth while. Also, intelligence is always a precursor of liberty, and I believe in liberty. I find several objections to the plan advanced by Mr. Fish.

In the first place, the school cannot even hope to get an equipment that would serve for much more than a toy. In the second, the instructors, with possibly rare exceptions, are unfit for the work. Mr. Fish feels it is impossible "for men to 'fake' teaching, as it is possible in the colleges." The writer has, in recent years, been in rather close contact with both industrial training schools and university work. In the latter there are some men who are "putting up a bluff"; but for pure and arrant faking, commend me to the very sort of trade school Mr. Fish represents. If the trade schools are going to teach engineering, they will have to reorganize. Nor will that be easy. In every large town may be found one or more men well equipped as engineers who would make excellent instructors for men employed in the power plant. To take mere boys and make a success of such work demands other qualities which not one in a hundred of these men possesses. A third stumbling block is to be found in the students themselves. I say this from observation not only in the classroom and the shop, but also in the locker room.

It is bad practice to try to teach a person an idea until that person has a desire to know it—until he realizes the value or necessity of such knowledge. The man who has put in a few months in the power plant is getting into this frame of mind. Then is the time to implant such education as is especially required by the power-plant engineer. The incentive is far greater than that of the boy and the results are out of proportion.

There is no reason why schoolhouses should be closed at 4 p.m., nor why they should be closed to the person over twenty; we all ought to go to school until we are fifty. Here is my plan for the special education of the power-plant engineer: Use the public-school buildings, laboratories, etc., in any town where there is sufficient demand. Hold evening sessions. Admit any actual worker. Make the age limit 100 years. Put on the faculty some engineers who are successful and capable. One advantage of this plan is that we should not be required to wait a generation for results; we can begin now, and results will follow quickly. A united demand in any locality ought to secure its adoption.

WILLIAM E. DIXON.

Cambridge, Mass.

Incompetent Repair Men

The other side of the story by G. H. Wallace, p. 499, Oct. 6, under the above title, is the incompetent engineers. I am reminded of some.

In a plant of about 5000 hp. a repair man rebored the valve chambers and refitted the valves of a 1200-hp. Corliss engine. The high-pressure admission valves did not close promptly when running on short cutoff. After the repair man had gone for the night the chief engineer removed the valves and draw-filed them with a coarse file. The valves, of course, worked easier and this operation was cheaper than to overhaul the vacuum dashpots, but the fit was spoiled and the valves leaked. Then the repair shop was blamed for putting a poor workman on the job. This engineer deserved credit for having worked his way up in the plant from coal passer, but he had never worked in a machine shop.

Another time I fitted piston rings to a Corliss engine of about 30-in. bore. The engineer demanded that they bear on the bottom of the grooves so that the weight of the piston was carried by the rings—on the theory that the piston should not bear on the bull ring because the greater bearing surface caused too much friction. I told him that it was not customary and suggested that if the friction was excessive with cast iron, to insert Allan red metal into the undercut grooves in the bull ring. He could not see the advantage of doing it that way, so I went ahead and gave him what he wanted.

An engineer should have sufficient knowledge of machine work to know when a repair job is done right, and before the man leaves the job. If the first man sent does not understand his business, telephone to the shop for one who does.

ALBERT T. ROWE.

East Glastonbury, Conn.

Referring to p. 499, Oct. 6, when the repairman broke the crosshead shoe and put in a large washer to hide the defect, the engineer was incompetent, to my mind. It was his duty to make the adjustment, but it took him three weeks to discover that the shoe was broken.

In the second case the repair man was blamed for putting the slide valves in wrong. We can hardly expect the average machinist to set all kinds of valves. The engineer must expect to give them his personal attention.

In the third case, the eccentric was not set right. The engineer should have set it himself. Let us hope that such things do not happen where licensed engineers are employed.

WILLIAM W. ELDERKIN.

Calgary, Alta., Canada.

Diagram from New Engines

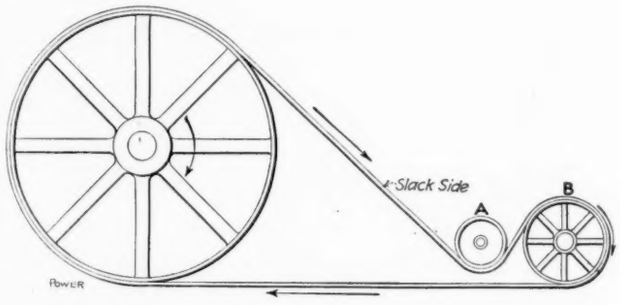
On page 427, Sept. 22, C. R. McGahey did not state the percentage of load carried at the time of taking the diagrams nor whether the boiler pressures and indicator springs were the same in each case. If he would run a steam-consumption test (not worked out from diagrams), he would probably find that No. 1 was considerably more efficient than No. 2. A little more lead would improve No. 1, but how would it affect the steam consumption which, after all, is the important factor? Perhaps with more load and the governor in a lower position, there would be enough lead, providing the valves are of the non-release type. The compression certainly speaks well for steam tightness.

E. R. PEARCE.

Rochdale, England.

Centrifugal Effect in Belts

I wish to add this query to my article on the above subject, on page 892, June 23: Why not use an idler, if necessary, of smaller radius than that of the smaller pulley, to merely hold the belt in position and maintain a negative curve permanently? I see no good reason why it cannot be done.



IDLER WITH SLIGHT TENSION ONLY

For example, in a drive where one pulley is considerably larger than the other, with the belt running very slack, the function of the idler pulley *A* is not as a tightener but merely to guide the belt in a circular path of a radius less than the radius of pulley *B*. It has been demonstrated experimentally at the Technical Institute of Charlottenburg, Germany, that idler pulleys do not add an appreciable drag on belts if they are properly designed and of a radius somewhat larger than that of the smaller transmission pulley. In these experiments, however, the idlers were doubtless loaded rather heavily, in accordance with the usual belief that tension is necessary on the non-pulling side.

It has been my experience that great initial tension is not necessary and is not as important as surface contact; hence, such an idler as proposed would be used simply to keep the negative curve in the belt, prevent it leaving the pulleys by centrifugal force, and losing contact entirely.

W. B. SCHAPHORST.

New York City.

Inquiries of General Interest

Making Equalizer Connection—In a compound-wound commutating pole machine where is the equalizer connection made?

P. D.

The equalizer connection would be taken off between the inter pole and series windings.

Amount of Blowoff of Pop Safety Valve—Why does a steam pop safety valve which is set to pop at 100 lb. pressure continue to blow off until the boiler pressure has become reduced to 80 lb.?

W. A. M.

Most pop safety valves are provided with a blowoff adjusting ring which can be adjusted for securing greater or less assistance from reaction of the escaping steam in holding the valve open. The amount of blowoff of the valve in question is undoubtedly due to the adjustment of the blowoff adjusting ring.

Hammering of Safety Valve—What causes a direct spring loaded safety valve to chatter?

W. N. R.

With properly constructed safety valves, a hammering or chattering is usually due to too great length of pipe connection to the valve. When the boiler pressure is at blowoff pressure and raises the valve, the pressure of steam delivered is reduced by the throttling effect of the pipe connection, causing the valve to rise and fall from alternation of built up and reduced pressure in the pipe connection.

Splitting of Condenser Tubes—What causes brass condenser tubes to split?

G. A. W.

In their manufacture the material of the tube is drawn out into a number of parallel elements slightly varying in thickness and texture according to the processes of manufacture. These cylindrical elements become separated from bending of the tube, as when the tube length expands more than the condenser shell or from difference of expansion of adjacent elements due to their difference of texture, difference of corrosion, or difference of temperature.

Replacing Valve Rod and Eccentric Rod Brasses—How can worn brasses be replaced by new ones on the valve rods and eccentric rod of a Corliss engine without changing the valve setting?

J. B.

Before removing the old brasses of a valve rod, tram the distance from center to center of the pins and carefully lay off the distance on a wooden rod for reference. After the new brasses are fitted in their places, adjust the length of each valve rod to obtain the distance formerly trammed between centers of the pins. To preserve the same length of eccentric rod, set one point of a tram in the center of the eccentric rod pin and with any convenient distance between the tram points, scribe a mark on the eccentric strap casting and transfer the distance to a rod for future reference and after the old brasses have been replaced by new ones, adjust the length of the eccentric rod to the formerly trammed distance from the mark on the eccentric strap casting to the center of the pin.

Bursting Pressure of Boiler—If a boiler 56 in. in diameter is made of ⅜-in. steel having an ultimate tensile strength of 58,000 lb. per sq.in. of cross-section, and the weakest part of the boiler is the longitudinal seam with an efficiency of 81 per cent. of the solid plate, what would be the bursting pressure?

M. P. C.

The resistance offered by 1 in. of length of the horizontal seam would be

$$81\% \text{ of } (\tfrac{3}{8} \times 1 \times 58{,}000 \text{ lb.}) = 17{,}617.5 \text{ lb.}$$

As the stress on each inch of length of the joint would be equal to the pressure per sq.in. multiplied by the radius of the boiler, then the limit of resistance would be reached when the pressure per square inch multiplied by the radius equals 17,617.5 lb., i.e., when pressure × 28 = 17,617.5 lb.; therefore, the bursting pressure would be

$$17{,}617.5 \div 28 = 629.2 \text{ lb. per sq.in.}$$

Heat Required to Convert Ice Into Steam—What quantity of heat would be required to convert a block of ice, at a temperature of 18 deg. F., and weighing 10 lb., into steam at an absolute pressure of 30 lb. per sq.in.?

P. N.

The specific heat of ice is 0.504, and to raise a pound of ice from 18 deg. F. to 32 deg. would require $(32 - 18) \times 0.504 = 7.056$ B.t.u. Upon reaching 32 deg. F. each pound of ice would require the addition of 144 B.t.u., called the latent heat of fusion, for conversion of the ice into water at 32 deg. F. For raising a pound of water from 32 deg. F. to the temperature of vaporization at 30 lb. per square inch absolute pressure would require the further addition of 218.8 B.t.u., and for converting the water into steam the additional heat required, called the latent heat of vaporization, would be 945.1 B.t.u. for each pound of water. Therefore, for converting 10 lb. of ice at 18 deg. F. into steam at 30 lb. pressure per square inch absolute would require

$$(7.056 + 144 + 218.8 + 945.1) \times 10 = 13{,}149.56 \text{ B.t.u.}$$

Percentage of Waste from Leaky Blowoff.—In a boiler plant which is operated at 100 lb. gage pressure, what would be the percentage of fuel wasted where the leakage of the blowoff valve amounts to 5 per cent. of the feed water?

R. J.

The percentage would depend upon the temperature of the feed water as well as on the boiler pressure. With steam at 100 lb. boiler pressure each pound of water in the boiler would contain about 309 B.t.u. above 32 deg. F., and each pound of steam would contain about 1188.8 B.t.u. above 32. Assuming the temperature of the feed water to be 150 deg. F., each pound of water wasted would have received

$$309 - (150 - 32) = 191 \text{ B.t.u.,}$$

and each pound of steam would require

$$1188.8 - (150 - 32) = 1070.8.$$

As the expenditure of heat realized would be 95 per cent. of 1070.8 = 1017.26 B.t.u. per pound of water fed to the boiler, and the waste of heat per pound of feed water would be 5 per cent. of 191 B.t.u. = 9.55 B.t.u., then

$$\frac{9.55 \times 100}{1017.26 + 9.55} = \frac{93}{100},$$

or practically 1 per cent. of the fuel would be wasted.

Steam Discharged by Safety Valve—What is the formula for determining the amount of steam escaping from a safety valve?

T. T. G.

Napier's rule for the discharge of steam through an unrestricted aperture from one pressure into another of three-fifths or less absolute pressure is

$$w = \frac{A\,P}{70}$$

in which

w = Weight of steam discharged, pounds per sec.;
A = Effective discharge area, square inches;
P = Absolute pressure of steam on the entrance side of the aperture.

The rule, therefore, holds true for the discharge of steam to the atmosphere, when the escaping steam is of greater pressure than ⅝ of 14.7, i.e., over 24.5 lb. absolute, or more than

$$24.5 - 14.7 = 9.8 \text{ lb. per sq.in. gage pressure.}$$

According to the formula, the discharge in pounds per hour would be

$$\frac{A\,P}{70} \times 60 \times 60 = 51.4\ P\ A.$$

Allowing for the resistance of the orifice the formula for weight discharged per hour would be

$$W = 51.4\ K\ P\ A.$$

The value of K for the standard safety valve orifice has been determined to be about 0.925, so that when the gage pressure is above 10 lb. per sq.in. the formula for the discharge of steam from a safety valve becomes

$$W = 51.4 \times 0.925 \times A \times P = 47.5\ A\ P \text{ lb. per hr.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--IV

Heating, Ventilation and Boiler Power

The first step in the design of any heating system is to decide upon the inside temperature it is desired to maintain in the coldest weather. For the Middle West and New England it is customary to assume zero as the minimum outside temperature which is likely to continue for any length of time, and a heating system designed on this basis will usually prove satisfactory. For temporary periods of colder weather, the amount of fresh air may be reduced, and the ventilating equipment be employed solely for heating purposes by circulating inside air. In the case of machine and forge shops, foundries, etc., where the men are more or less actively engaged, a drop of 10 deg. or so from the normal inside temperature will not cause any particular discomfort.

Unless the building is particularly exposed to high winds, or is in a locality where the temperature frequently falls to a lower point, a minimum of zero may be assumed and the heating equipment based on the following inside temperatures under this condition: Offices and drafting room, 70 deg.; paint shop, 80 deg.; machine and pattern shops and carpenter's shop, 60 deg.; foundry and forge shop, 50 deg.; storage for patterns and general supplies, 40 deg.

Heat Losses

The heat loss from a building is due to two principal causes, first, transmission through walls and windows, and second, that due to leakage. Transmission depends chiefly upon the thickness and material of the walls and the difference between the inside and outside temperatures; while leakage is affected more by the tightness of the building construction and the strength of the winds. It is also well to add something to the capacity of the plant, say 10 per cent., for "warming up" when the heat is shut off at night.

There are various tables of heat transmission prepared to cover a wide range of conditions. The following has been abridged from one of these and applies especially to the conditions found in manufacturing plants.

TABLE I—HEAT LOSS IN B.T.U. PER SQ.FT. PER HR.

Material and Thickness	Diff. Between Inside and Outside Temp., Deg. F. 40	50	60	70
8-in. brick wall	18	22	27	31
12-in. brick wall	13	16	20	23
16-in. brick wall	10	13	16	19
4-in. reinforced concrete	39	45	57	65
8-in. reinforced concrete	23	29	35	40
12-in. reinforced concrete	17	21	26	30
Tar and gravel roof	12	15	18	21
Slate on matched boards	12	15	18	21
Unlined metal	32	40	48	56
Cement floor	6	8	10	12
Single window	50	60	73	85
Single monitor window	56	70	84	98
Single skylight	42	52	63	73

The heat loss by leakage can only be estimated approximately by multiplying the heat loss by factors based on experience, and for average conditions the following may be used:

Exposure to winds	1.12
Leakage with good construction	1.00
Leakage with fair construction	1.10
Leakage with poor construction	1.20
For warming up	1.10

Computations for Heat Loss

Figs. 1, 2 and 3 are diagrams representing sections through the machine shop, foundry and forge shop, respectively, and give approximate dimensions. In making the computations it is assumed that all dimensions are taken from the architects' drawings, as would be the case in practice, and the work is given for the purpose of illustrating the methods employed. The factors for transmission and leakage are taken from the data given previously, it being assumed that the construction is of the best so that only "exposure to winds" and "warming up" need be provided for when computing the leakage.

Machine Shop—Constructed of reinforced concrete, 12 in. thick for the first story and 8 in. for the second; monitor walls of unlined metal; roof, tar and gravel; floor, cement; and all windows single. The building to be maintained at 60 deg. in zero weather. The heat loss may be computed as follows:

Wall, 12 in. thick	10,000 sq.ft. × 26 =	260,000
Wall, 8 in. thick	8,000 sq.ft. × 35 =	280,000
Wall, monitor	5,000 sq.ft. × 48 =	240,000
Windows, main walls	9,000 sq.ft. × 73 =	657,000
Windows (monitor)	2,500 sq.ft. × 84 =	210,000
Roof	40,000 sq.ft. × 18 =	720,000
Floor	40,000 sq.ft. × 10 =	400,000
Total B.t.u.		2,767,000

Correcting for exposure to winds and warming up, gives

$$2{,}767{,}000 \times 1.12 \times 1.10 = 3{,}408{,}944 \textit{ B.t.u. per hr.}$$

or in round numbers, 3,409,000 B.t.u.

If special ventilation is provided with zero conditions outside, additional heat will be required for each complete air change per hour. The cubic contents is 1,760,000 cu.ft., and as one heat unit will raise the temperature of 55 cu.ft. of air one degree

$$1{,}760{,}000 \times \tfrac{60}{55} = 1{,}920{,}000 \textit{ B.t.u.}$$

will be required to raise the temperature of this volume of air through 60 deg. Changing this air twice an hour would require 3,840,000 B.t.u.

Foundry—Walls of reinforced concrete 8 in. thick; all other construction the same as before. The inside temperature will be 50 deg. in zero weather.

Wall, 8 in. thick	7,000 sq.ft. × 29 =	203,000
Wall, monitor	2,000 sq.ft. × 40 =	80,000
Windows, main walls	2,000 sq.ft. × 60 =	120,000
Windows (monitor	1,000 sq.ft. × 70 =	70,000
Roof	15,000 sq.ft. × 15 =	225,000
Floor	15,000 sq.ft. × 8 =	120,000
Total B.t.u.		818,000

Correcting for exposure and warming up gives

$$818{,}000 \times 1.12 \times 1.10 = 1{,}007{,}776$$

or practically 1,007,800 B.t.u. per hr.

Ventilation for this building is to consist of four changes of air per hour for a stratum 10 ft. high over the entire floor, which amounts to

$$100 \times 150 \times 10 \times 4 = 600{,}000 \textit{ cu.ft.}$$

of air per hour and requires

$$600{,}000 \times \tfrac{50}{55} = 545{,}454 \textit{ B.t.u.}$$

which we will call 545,000 B.t.u.

Forge Shop—Construction, inside temperature and ventilation the same as for the foundry:

Wall, 8 in. thick	4,000 sq.ft. × 29 =	116,000
Wall, monitor	800 sq.ft. × 40 =	32,000
Windows (main walls)	2,000 sq.ft. × 60 =	120,000
Windows (monitor)	400 sq.ft. × 70 =	28,000
Roof	500 sq.ft. × 15 =	7,500
Floor	500 sq.ft. × 8 =	4,000
Total B.t.u.		307,500

Correcting for exposure and warming up gives

$307{,}500 \times 1.12 \times 1.10 = 378{,}840$ *B.t.u. per hr.*

The air supply for ventilation equals

$50 \times 100 \times 10 \times 4 = 200{,}000$ *cu.ft. per hr.*

requiring

$$200{,}000 \times \tfrac{50}{55} = 181{,}818 \text{ } B.t.u.$$

or say 181,800 B.t.u.

Offices—Walls of 12-in. concrete; inside temperature 70 deg.; ventilation, six changes per hour.

Wall	1800 sq.ft. ×30 =	54,000
Windows	400 sq.ft. × 85 =	34,000
Total B.t.u.		88,000

Correcting for exposure and warming up gives

$88{,}000 \times 1.12 \times 1.10 = 108{,}416$ *B.t.u. per hr.*

or approximately 108,400 B.t.u. The air supply for ventilation is

$60 \times 70 \times 16 \times 6 = 403{,}200$ *cu.ft. per hr.*

and requires

$$403{,}200 \times \tfrac{70}{55} = 513{,}164 \text{ } B.t.u.$$

which is approximately 513,200 B.t.u.

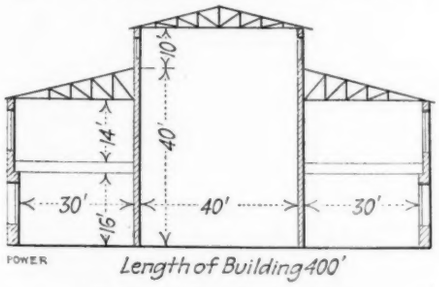


FIG. 1. MACHINE SHOP

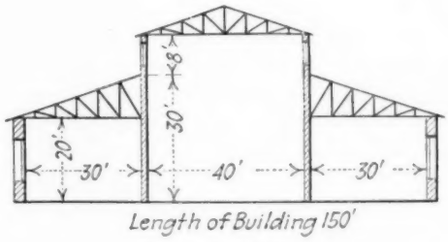


FIG. 2. FOUNDRY

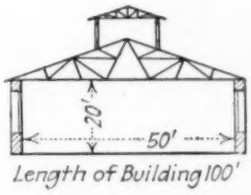


FIG. 3. FORGE SHOP

Taking up the other rooms to be heated and ventilated, in a similar manner, the following results are obtained:

Tool Room—Temperature, 70 deg., air supply, four changes per hour.

For heating, 108,240 B.t.u. per hr.; for ventilation, 268,800 cu.ft. per hr., requiring 342,100 B.t.u.

Drafting Room—Temperature, 70 deg., air supply, six changes per hour. For heating, 112,300 B.t.u. per hr.; for ventilation, 378,000 cu.ft. per hr., requiring 481,100 B.t.u.

Pattern Shop—Temperature, 60 deg.; air supply, four changes per hour. For heating, 96,300 B.t.u. per hr.; for ventilation, 252,000 cu.ft. per hr., requiring 274,900 B.t.u.

Carpenter Shop—Temperature 60 deg.; no special ventilation. For heating, 132,800 B.t.u. per hr.

Paint Shop—Temperature, 80 deg.; ventilated from machine-shop system. For heating, 45,000 B.t.u. per hr.

Storage Space—Temperature, 40 deg.; no ventilation. For heating, 330,000 B.t.u. The storage space to be heated includes the pattern storeroom and that adjacent to the carpenter shop. The other storehouse is for stock and is not heated.

The first step in computing the boiler power is to find the total heat units required for both heating and ventilating in zero weather and see how it compares with the heat available in the exhaust steam. In computing the heat requirements two changes of air per hour in the main shop in zero weather, with the idea of increasing this up to three changes as the outside temperature rises, will be assumed. For the other buildings and departments the heat quantities first computed will be taken. These are as follows:

	B.t.u. per Hr.
Machine shop heating	3,409,000
Machine shop ventilation	3,840,000
Foundry heating	1,007,800
Foundry ventilation	545,000
Forge shop heating	378,840
Forge shop ventilation	181,800
Office heating	108,400
Office ventilation	513,200
Tool room heating	108,240
Tool room ventilation	342,100
Drafting room heating	112,300
Drafting room ventilation	481,100
Pattern shop heating	96,300
Pattern shop ventilation	274,900
Carpenter shop heating	132,800
Paint shop heating	45,000
Storehouse heating	330,000
Total	11,906,780

As the exhaust is to be used for heating, and the buildings are somewhat scattered, it will be best to employ a vacuum system with a suction attached to the main return. This will prevent any additional back pressure from being thrown upon the engine and also insure a free return of condensation to the receiving tank without trouble from water-hammer.

With this arrangement we may count on a maximum steam pressure of zero gage, or that of the atmosphere, the latent heat of which is found from a steam table to be 970 B.t.u. With this assumption the total steam requirements for heating and ventilation in zero weather will amount to

$11{,}906{,}780 \div 970 = 12{,}275$ *lb. per hr.*

The steam consumption, or water rate, of an engine varies according to a number of conditions, depending upon the type, size, steam pressure, speed, cutoff, etc., and if possible should be obtained from the makers for the particular machine to be used. If the make has not been decided upon, Table 2 may be used, which gives average values for engines of medium-size, first-class design:

TABLE 2—AVERAGE STEAM CONSUMPTION OF SIMPLE AND COMPOUND ENGINES

Type of Engine	Lb. Steam per I. Hp.-Hr. Noncondensing	Condensing
Simple high speed	30 to 34	22 to 26
Simple medium speed	28 to 32	21 to 25
Simple Corliss	26 to 30	20 to 24
Compound high speed	24 to 28	18 to 22
Compound medium speed	23 to 27	17 to 21
Compound Corliss	22 to 26	16 to 20

In the case of the engine selected, compound moderate speed, a water rate of 18 lb. per i.hp.-hr. was assumed. The corresponding rate noncondensing, which would be the condition under which it would operate during the

heating season, is found from Table 2 to be 24 lb., the next to the lowest figure being taken in each case on account of the large size of the engine.

The energy in the steam available in the exhaust from an engine will vary from 80 to 90 per cent. of that supplied from the boiler, depending upon the cylinder condensation. Taking an average of 85 per cent. in the present case, the energy, or we may say the pounds of steam available, would be

$$670 \times 24 \times 0.85 = 13{,}668 \text{ } lb. \text{ } per \text{ } hr.$$

which is slightly more than the maximum requirements for heating and ventilation. This means that the boiler power may be computed solely upon the steam requirements for power and lighting and that nothing need be added for heating.

In case of the lighting plant there is a total of 158 i.hp. of compound high-speed engines running at one time. During the heating season, which is practically the only time they will be used, they will run condensing and from Table 2 a water rate of 20 lb. per i.hp.-hr. may be assumed. This will amount to

$$158 \times 20 = 3160 \text{ } lb.$$

of steam per hour. Adding this to that required by the main engine makes

$$16{,}080 + 3160 = 19{,}240 \text{ } lb.$$

Steam auxiliaries, such as feed and condenser pumps, will use approximately 5 per cent. of the above, making the total maximum weight of steam to be supplied by the boilers

$$19{,}240 \times 1.05 = 20{,}202 \text{ } lb. \text{ } per \text{ } hr.$$

Assuming a boiler pressure of 120 lb. gage, and a feed-water temperature of 190 deg., the factor for equivalent evaporation from and at 212 deg. is found from a table of such factors to be 1.066, which means that

$$20{,}202 \times 1.066 = 21{,}535 \text{ } lb.$$

must be evaporated from and at 212 deg. per hour by the boilers. The boiler-horsepower is now easily determined, being

$$21{,}535 \div 34.5 = 624$$

a normal rating of 600 hp. would be sufficient.

Number and Size of Boilers

The type of boiler to be used will depend somewhat upon local conditions and the preference of the owners.

Experience has shown that when boilers of any of the well known types are equally well designed and proportioned for the work to be done, are operated with the same skill and provided with the same quality of fuel, there will be very little difference in operating economy.

The water-tube boiler has the advantage of greater safety and requires less space, and for these reasons is more frequently employed in office buildings and institutions. In the present case, either water-tube or fire-tube boilers should give satisfaction, but for purposes of illustration, we will use the horizontal fire-tube boiler.

Dividing the total power into five units calls for 120 hp. each. In plants of large size a spare boiler should always be provided for cutting in in case of repairs or cleaning, bringing the number in the present case up to six. Based on 12 sq.ft. of heating surface per horsepower, they should be 72 in. in diameter and contain ninety-eight 3½-in. tubes, 16 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Uncle Tom Edison, our well known and respected inventor, has recently appeared in print quite some. We have followed his utterances with interest until now. Now, "Mr. Edison says we are too rich." Bet this is his very latest invention.

Instead of worrying about turkey for Thanksgiving it looks as though us engineers had reason for thanksgiving that Turkey is no nearer.

John J. Bjoblie has invented a headlight to be coupled with the automobile's steering gear so that it may be automatically shifted with the movement of the front wheel. You'd think that Beejay would have first directed his inventiveness toward improving the articulate mechanism of his name. 'Spose the papers spell it correctly?

With those who go down to the sea in ships, who have fought their way to the uttermost ends of the earth, enduring privation and meeting death—with these heroes and martyrs to the glory of discovery is the marine engineer! Of the nine men recently rescued in the Arctic, two were engineers and one a fireman. And they and their like would go back tomorrow.

"Women must end all war!" is the latest dictum of the suffragists. When you go home from the plant tonight, you and the missis might "discuss" this topic—you know best. It needs solution. Arnica is a good solution, but— Say, p'r'aps you hadn't better start anything.

Following the Roentgen rays comes Ulivi's rays. Toddling along down the alphabet, somebody will soon be discovering the "H raise." Mebbe this somebody is one of the nine gods of war.

That veteran electrical engineer, C. O. Mailloux, recently put up a strong defense for the isolated plant at the recent meeting of the A. I. E. E. He believes, as we do, that both services have their particular place, but that there are many places where one is better than the other.

Who says the churches are losing their drawing power? Not in Brooklyn. Two crooks drew out the poor-box money, a cop drew his revolver and the black maria drew the whole bunch to the judge, who drew up a scheme to tuck 'em away for two years. Some drawing.

Doctor Humphreys, of Stevens Institute, recently wrote an excellent prescription for sick public-service commissions: "Compose them of common-sense men, broadly trained, broad-minded, fair, and competent as investigators (an unusual qualification); and in each commission there should be men fully qualified in the theory and practice of the professions of engineering, law, business, finance and accountancy."

The London "Lancet" says that smoking in moderation "does much to allay the restlessness and muscular irritability engendered by mental and physical fatigue." It quotes Huxley, who was some pumpkins along the thinking line, as in favor of it. If you can't smoke you might show this to the boss—but first find out if he knows whether Huxley is the said pumpkin, or just a new variety of chewing gum.

Twenty-six states now have compensation acts, and "they have done more than any other thing to bring about earnest efforts for the prevention of industrial accidents." Reduced to dollars and cents, anything that mutually affects the employer's cash drawer and the employee's envelope usually gets a fair tryout.

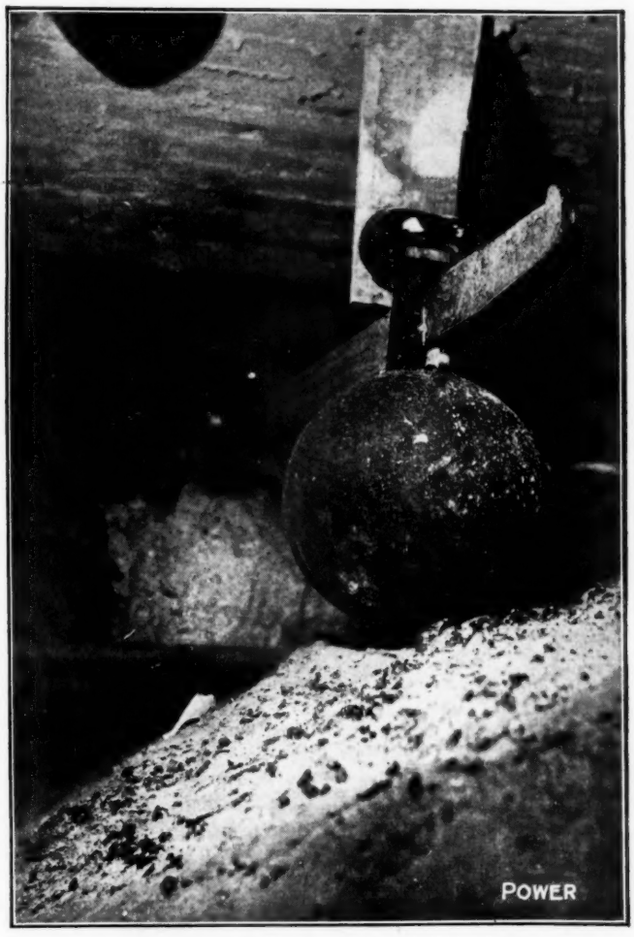
In Wisconsin, for instance, for the past 28 months nearly $600,000 has been paid to workingmen or their dependents in 6894 cases. Only 154 cases had to be decided by the Industrial Commission. All the others were settled amicably. Hooray for the better understanding!

Boiler Explodes under Sidewalk

Shortly after nine o'clock, Oct. 27, a 250-hp. double-furnace dry-back, Scotch marine type boiler exploded at the Continental Hotel, Forty-first St. and Broadway, New York City, causing the death of two men and the serious injury of two others. The boiler was one of a pair used in connection with the hotel heating and electric plant.

The conditions previous to the accident were as follows: The tubes, of which there were 108, had caused considerable trouble and it was decided to retube both boilers. The work on the one which failed had been completed; it had been given a hydrostatic test of 188 lb. and was passed by the inspectors for the police department and the Hartford Steam Boiler Inspection & Insurance Co. A steam pressure of 125 lb. was allowed. The boiler was put in service on Oct. 18, just ten days previous to the accident.

The immediate cause of the explosion was a bulging outward of the rear tube sheet, which pulled entirely away from the tubes in the central area where the bulging was naturally greatest. All the tubes showed signs of some movement. The new tubes had not been beaded over and, therefore, supported the tube sheet only by the friction of the metal. The staying effect was further reduced on account of the tubes being considerably under size and shims had to be used around them to fit the holes in the tube sheet. There was no stay rod (or socalled stay tube) in the tube area. The boiler was not equipped with a fusible plug.



LEVER HELD DOWN BY BOARD

A representative of "Power" visited the plant and was present when Lieutenant Van Keuren, in charge of the boiler squad, with his inspectors and one from the Hartford company, made their inspection and had their attention called to the discovery previously made by one of the police inspectors of a gag on the safety valve. This was a board 12 to 14 in. long wedged endwise between the lever of the safety valve and the brick arch which forms the ceiling of the boiler room and base for the sidewalk. With this prop in position it would be impossible for the valve to operate and relieve the boiler in case of over-pressure, as it had been cut and used for the purpose of holding the valve closed against the hydrostatic pressure during the test referred to, and there was no locked pop valve attached to the boiler.

The chief engineer disclaimed any knowledge of when the prop might have been put there, but stated under oath that he himself had removed it and laid it on the top of the boiler after the inspection test was over. He further said that on Thursday the pressure had caused the safety valve to operate, substantiating his statement that the gag had been removed after the test and must have been replaced subsequently by some one unknown to him.

It is surprising that such conditions could exist under the close supervision of the inspectors of the insurance company carrying the risk. Later, the chief engineer and the night engineer (who is in a hospital in a serious condition) were put under arrest charged with homicide, and a warrant is out for a third man.

Exhibits from Europe Reach San Francisco

On Sept. 24 Secretary of State Bryan announced that no foreign country had withdrawn from its participation in the Panama-Pacific International Exposition.

Since then many large consignments of costly exhibits from European and other countries have reached San Francisco and chartered steamers will soon leave with great loads of exhibits for that city. In view of the apprehension for the success of the fair since the outbreak of hostilities in Europe the following items have been selected from a statement just issued by the exposition authorities, because they relate to the participation of the affected countries:

Many European nations, associations of exhibitors, and individual exhibitors will be represented at the exposition and there will be many important entries from Europe in the various events. Several of the European nations have increased their funds for participation since the outbreak of the war; others have made appropriations contemplated but not ratified before the commencement of the conflict.

In addition, an unprecedented number of selective exhibits will be shown from South America, the United States, Canada and the Oriental countries, the plans for exhibition having been greatly amplified during the past six weeks.

During the week ending Oct. 11 the first shipment of exhibits reached San Francisco from Holland. Shipments of exhibits during the week were received from Luxemburg, Ireland and France. A large consignment of exhibits from London was installed in the Palace of Mines. Five carloads of social economy exhibits, made under the supervision of Dr. Philip Rauer of Stuttgart, have reached the city. More than five hundred tons of exhibits and materials for the Japanese displays and pavilions are leaving Japan in two shipments, one of which is scheduled to arrive within a few days.

The construction of the exposition is far advanced. The main exhibit section is completed; the installation of the works of famous sculptors, embracing more than eight hundred different pieces and groups of statuary, is 75 per cent. completed; the landscaping of the exposition grounds and courts is 82 per cent. completed; hundreds of thousands of acacias, rhododendrons, tree ferns, orange trees, date palms, rare shrubs and ornamental plants, brought from the far corners of the world, are now thriving in their new environment.

Work has progressed well upon the "Zone," the amusement section, which gives evidence of its high educational character and great intrinsic worth; an outlay of $10,000,000 will be made in this section when completed and more than seven thousand persons will be employed there during the exposition.

In the section devoted to the pavilions of the nations and the buildings of the American states many of the edifices are finished and others are rapidly nearing completion.

The German Kali Syndicate Building, constructed in part by the German government, is more than half finished and will be rushed to completion. The exposition headquarters in Berlin, established by important German industries, received applications for exhibit space from leading German firms two months after the outbreak of the war.

The government of the Netherlands has increased its appropriation by an additional $300,000.

Since war was declared Italy has formally ratified the appropriation of $400,000 for the Italian national display.

Commissioner J. Heyerdahl-Hansen, of Norway, who recently arrived in San Francisco, brought official notice of Norway's determination to carry through its plan for participation regardless of the state of war.

A comprehensive exhibit of roses and bulbs is now ready in Belgium for shipment.

France sent word within a few weeks after the declaration of war that there would be no change in her plans and entries were received in the live stock, horticultural and other departments during the latter part of September and subsequently.

Representatives of British exhibitors arrived in San Francisco as early as August to inaugurate the plans for presenting their exhibits and subsequent shipments of exhibits have reached that city.

The Japanese government made an original application for 144,000 square feet of exhibit space in all of the exhibit palaces. Commissioner Ishii, after the outbreak of the war, arranged for an additional space of 21,419 square feet in the Palaces of Food Products, Manufactures and Horticulture. The Japanese Commission reports that the most representative displays of Japan have been gathered from every portion of the Empire.

France and England are sending rare varieties of hot house plants and Japan will add a collection of lilies to the horticultural display in the palace.

Entries in the livestock department have been received since the outbreak of the war from Brittany and Boulogne, France.

The Grand Duchy of Luxemburg, despite the war, has prepared and shipped an exhibit to compete for the $1000 prize offered for the most perfect variety of rose originated for and exhibited at the exposition.

ENGINEERING AFFAIRS

Training Class for Trade Teaching—During 1913 and 1914, Pratt Institute, Brooklyn, N. Y., tried the experiment of having a training class for teachers of the different trades in industrial schools. This class consisted of 17 men, between the ages of 24 and 40, who were working at various trades during the day and were brought together in an evening class to receive instruction in the principles of teaching as applied to the industrial school. The class met three times a week for 24 weeks, each session being two hours long. The instruction did not include shop-work practice or related trade subjects, but was confined to the principles of trade teaching.

The training given consisted of two parts: Practice teaching in the New York evening trade schools one evening each week. (The majority of the class taught two evenings a week, the second evening being optional.) Class work at Pratt Institute two evenings each week. The latter was divided into two parts: Demonstration work in the form of practice teaching before the class, and conference and lecture work, consisting of discussions, readings and occasional lectures upon such subjects as:

The organization and equipment of the trade school shop.
Analyzing a trade for the purposes of instruction.
The commercial product.
The project scheme.
The teaching of "related work."
Basis of the course of study.
The organization of the industrial school.
How to handle the industrial school boy.
The qualifications of the industrial school teacher.
Types of schools—their organization and function.
What is education?
The difference between vocational education and general education.
The difference between vocational education on the one hand and prevocational education, practical arts and manual training on the other.

This course will be continued next year on essentially the same plan and information for prospective students can be secured by addressing the institute.

PERSONALS

C. M. Ripley, formerly with Pattison Bros., consulting engineers, is now with the Richard D. Kimball Co., consulting engineers, New York City.

George W. Stevenson, formerly master mechanic at Thomas A. Edison's Silver Lake chemical plant, Newark, N. J., has accepted a position as master mechanic with the Empire Steel & Iron Co., Oxford, N. J.

L. B. Lucas, Toronto, Ohio, has been appointed a member of the Hydro-Electric Power Commission of Ontario, replacing Hon. J. S. Hendrie, who has been appointed Lieutenant-Governor of the Province of Ontario.

F. C. Herrman has resigned as chief engineer of the Spring Valley Water Co., San Francisco, Calif., and will engage in engineering practice, specializing in water supply, irrigation, drainage, sanitation and valuation, with offices in the Merchants' Exchange Building, in San Francisco.

BUSINESS ITEMS

Mr. Robt. E. Mullane has been elected president of the D. T. Williams Valve Co., Cincinnati, Ohio, succeeding Mr. D. T. Williams, who recently resigned.

The Flanner Water Tube Boiler Co. has moved its business to Akron, Ohio. A Chicago office will be opened at 1651 Marquette Building, with Mr. A. H. Chas. Dalley in charge.

The Wm. Powell Co., Cincinnati, Ohio, has recently issued the Powell Whistle Booklet which gives the complete story of Powell steam whistles and whistle valves. A copy is sent to anyone on request.

The Smooth-On Mfg. Co., Jersey City, N. J., is sending out a circular showing how the Drake Cake Bakery in Brooklyn used Smooth-On Iron Cement No. 7 for waterproofing, dust proofing and hardening concrete.

In order to keep in closer touch with its customers the Uehling Instrument Co. has discontinued its selling connection with the Uehling Sales Co. All future transactions will be handled by the main office in Passaic, New Jersey.

An interesting bulletin sent out by the Yarnall-Waring Co. Chestnut Hill, Philadelphia, Penn., shows a record of 997 Simplex "Seatless" Blow-Off Valves sold to a total of only 35 concerns, giving an idea of large blow-off installations this company is making.

The Duquesne Light Co., Pittsburgh, Penn., has placed an order with the Yarnall Waring Co., Mermaid Ave., Chestnut Hill, Philadelphia, Penn., for two 300,000 lb. per hour "Lea" V-Notch Recording Liquid Meters for the measurement of condensate in their Brunats Island Power Plant. They had previously installed three meters of the same capacity.

The Builders Iron Foundry, Providence, R. I., is getting out a new Hot Water Bulletin No. 85. It is a brief but comprehensive pamphlet on the Venturi Hot Water Meter, giving a short history of the meter, the explanation of the principle involved, the different types of instruments, their methods of installation, and several calibration tests. Also shows a number of interesting installations. Sent on request.

The B. F. Goodrich Co., Akron, Ohio, recently made a shipment of 18 tons of Longlife belting in response to one cable order from abroad. In this connection it is interesting to note that this company turns out five miles of belt a day, has fifteen miles of belt in process of manufacture and has about fifty miles of belting under orders. 15,000 persons are employed in the Goodrich plant.

"Westinghouse Electric Motors for Machine Tool Service" is the title of an exceedingly comprehensive pamphlet, with an art cover, which has been issued by the Westinghouse Electric & Mfg. Co. This book, which is profusely illustrated, describes the electrification of a machine shop, going into some detail as to the type of motor to be selected for each machine, and a recital of the characteristics of direct and alternating-current motors as applied to this work.

The Westinghouse Electric & Mfg. Co. has just issued Leaflet No. 3749, covering Westinghouse Synchronous Booster Rotary Converters, in which this type of apparatus is very fully described and illustrated. The advantages of this type of machine are given together with a detailed account of its method of operation and construction details. A cross section view also gives a clearer understanding of its construction. A number of installation views are also shown.

The National Transit Co. Oil City, Penn. is building four horizontal duplex compound outside center packed plunger oil pumps for the Panama Canal Terminal Pumping Stations. There will be a pumping station at the Atlantic and at the Pacific Terminal of the Canal and two of the above pumps are to go in each station for pumping fuel oil to and from the oil ships and the oil tanks on shore. Cosden & Co., producers and refiners in high-grade petroleum, have recently purchased from the National Transit Co. two 100-hp. horizontal twin gas engines, each direct connected to a vertical triplex single-acting power pump.

The Bruce Macbeth Engine Co., Cleveland, Ohio, has recently installed the Meriam Steam Process of generating low pressure steam by means of gas engines for the Microscope Co., Cleveland; Steffan Shoe Co., Buffalo, N. Y.; Strootman Shoe Co., Buffalo, N. Y.; C. W. Downey (garage), Cleveland; J. P. Eustis Mfg. Co., Cambridge, Mass.; Detroit City Gas Co., Detroit, Mich.; Wellington Milling Co., Wellington, Ohio; The Ohio State Reformatory, Mansfield, Ohio; Chisholm Steel Shovel Works, Cleveland; Consumers' Ice & Cold Storage Co., Lexington, Ky.; American Glove Co., Dunkirk, N. Y.; Younglove Building, Cleveland; Wood & Spencer Co., Cleveland; Northside Cameraphone Building, Pittsburgh; U. S. Paper Goods Co., Cincinnati, Ohio; Swarthmore College, Swarthmore, Penn.; Cleveland Steel Barrel Co., Cleveland; Fessenden Light & Power Co., Fessenden, North Dakota.

NEW EQUIPMENT

CENTRAL STATES

The Willard Storage Battery Co., Cleveland, Ohio, will construct a power house, estimated to cost $5000.

It is reported that the Fairbanks-Morse Mfg. Co., Beloit, Wis., will remodel its power house preparatory to installing new boilers in the early spring.

Frank H. Josslyn and LeRoy Herrod, Oshkosh, Wis., according to press reports, have purchased the Weyauwega